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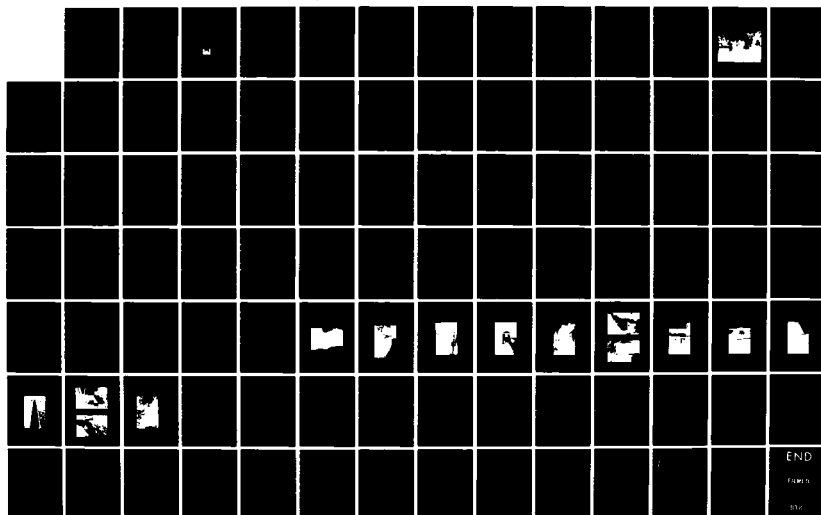
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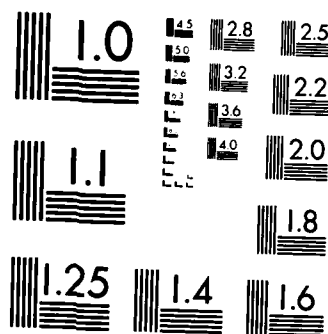
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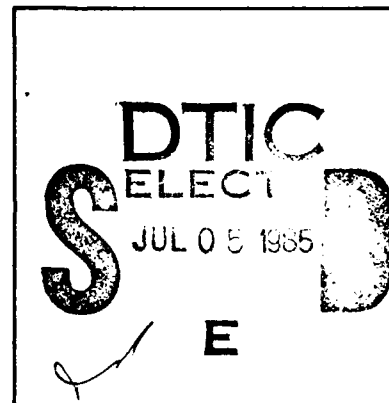
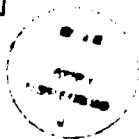
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CONNECTICUT RIVER BASIN  
NORWICH, VERMONT

NORWICH RESERVOIR DAM

VT 00157  
VTDWR 146-1

PHASE I INSPECTION REPORT  
NATIONAL DAM INSPECTION PROGRAM



DEPARTMENT OF THE ARMY  
NEW ENGLAND DIVISION, CORPS OF ENGINEERS  
WALTHAM, MASS. 02154

AUGUST 1981

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)  The dam is a concrete arch with thrust walls and a concrete crib with earth backfill. The dam si about 200 ft. long with a maximum height of 28 ft. The dam is small in size with a high hazard potential. The dam is in poor condition at the present time. There are various remedial measure and recommendations which must be undertaken by the owner.		

NATIONAL DAM INSPECTION  
PHASE I INSPECTION REPORT

Identification No.: VT00157  
VTDWR No.: 146.1  
Name of Dam: Norwich Reservoir Dam  
Town: Norwich  
County and State: Windsor, Vermont  
Stream: Charles Brown Brook, a tributary of  
Blood Brook, which is a tributary  
of the Connecticut River  
Date of Inspection: May 14, 1981

BRIEF ASSESSMENT

The Norwich Reservoir Dam is located on Charles Brown Brook approximately one mile upstream of Norwich, Vermont. The dam is a concrete arch with thrust walls and a concrete crib with earth backfill. The overall length of the dam is approximately 200 feet with a maximum height of 28 feet. The weir length of the overflow spillway is 45 feet. The dam is capable of impounding a maximum of 37.4 acre-feet. The outlets consist of a 10-inch water supply main and a 20-inch-diameter pond drain.

The water impounded by this dam is presently used for water supply for the Town of Norwich. The Town plans to take this dam out of service in the near future. The dam is owned by the Norwich Fire District Number 1.

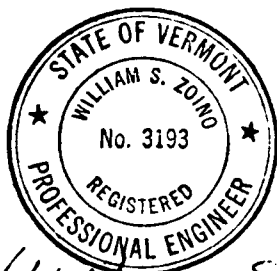
The drainage area of the dam covers 5.2 square miles of mountainous woodland. The maximum impoundment of the dam is 37.4 acre-feet. The dam is SMALL in size, and its hazard classification is HIGH because of the potential for economic loss and loss of more than a few lives in the event of a dam failure.

The appropriate test flood for a dam classified small in size with a high hazard classification would be between one half of the Probable Maximum Flood (PMF) and the Probable Maximum Flood. The one-half PMF has been adopted as the appropriate test flood for this dam.

The peak test flood discharge of 5,750 cfs will produce a maximum water surface at elevation 725.2 (NGVD) and will overtop the dam by 3.7 feet. The spillway is capable of passing 15% of the test flood without overtopping.

The dam is in poor condition at the present time. It is recommended that the owner retain the services of a qualified registered professional engineer to conduct a detailed hydraulic and hydrologic study to further define the need and means to increase the spillway capacity; investigate the seepage through the left embankment; investigate the structural stability of the gatehouse, the spillway, and the left training wall; evaluate the condition of the right training wall; prepare plans for renovation or repair of those structures; and develop a method to remove trees and stumps. Remedial measures to be undertaken by the owner include immediately checking the operability of the outlet works through their full range, removing brush from embankments; implementing annual maintenance and inspection programs; and immediately developing a formal system to warn the appropriate officials and the downstream residents in the event of an emergency.

These engineering studies and remedial measures should be implemented by the owner within one year of the receipt of this Phase I Inspection Report.



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California Registration No. 21006

## PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C., 20314. The purpose of a Phase I Investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigations, and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need from such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions be detected.

Phase I Inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the Spillway Test Flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. Because of the magnitude and rarity of such a storm event, a finding that a spillway will not pass the test flood should not be interpreted as necessarily posing a highly inadequate condition. The test flood provides a measure of relative spillway capacity and serves as an aide in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

The Phase I Investigation does not include an assessment of the need for fences, gates, no trespassing signs, repairs to existing fences and railings, and other items which may be needed to minimize trespassing and provide greater security for the facility and safety to the public. An evaluation of the project for compliance with OSHA rules and regulations is also excluded.

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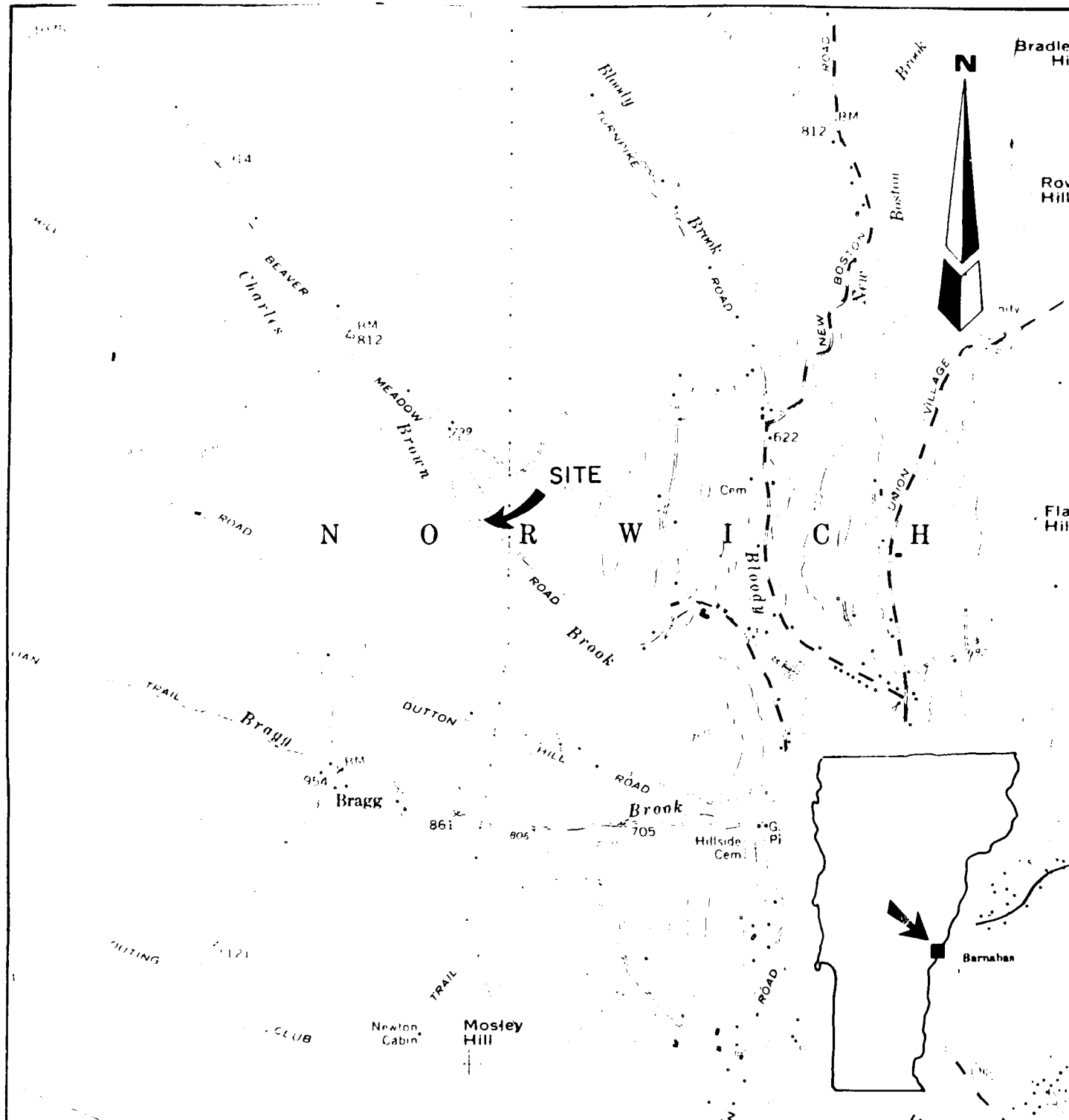
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Overview of Dam



FROM: USGS HANOVER, VT-NH  
QUADRANGLE MAP

GOLDBERG-ZOINO & ASSOCIATES, INC.  
GEOTECHNICAL-GEOHYDROLOGICAL CONSULTANTS  
NEWTON UPPER FALLS, MASSACHUSETTS

U.S. ARMY ENGINEER DIV. NEW ENGLAND  
CORPS OF ENGINEERS  
WALTHAM, MASSACHUSETTS

NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

## LOCUS PLAN

FILE No. 2605

NORWICH RESERVOIR DAM

NORWICH, VERMONT

SCALE AS NOTED

DATE MAY 1981

## Section 4: Operational and Maintenance Procedures

### 4.1 Operational Procedures

#### (a) General

No written operational procedures exist for this dam. The outflow is normally uncontrolled. The water supply is generally open, and the reservoir drain is closed.

#### (b) Description of any Warning System in Effect

There is no warning system in effect at this dam.

### 4.2 Maintenance Procedures

#### (a) General

No formal maintenance program exists for the dam, and maintenance is performed on an "as needed" basis.

#### (b) Operating Facilities

No formal maintenance program exists, and maintenance is performed on an "as needed" basis.

### 4.3 Evaluation

Additional emphasis on routine maintenance will assist the owner in assuring the long-term safety of the dam and operating facilities. A formal, written, downstream emergency warning system should be developed for this dam.

- (a) Severe deterioration of the left training wall.
- (b) Deterioration of the right training wall.
- (c) Partial structural failure of the gatehouse foundation.
- (d) Condition of spillway not determined due to sheet flow.
- (e) Trees and brush growing on embankments may damage slopes by uprooting or rotting of roots.
- (f) Seepage through left embankment.
- (g) Gates are reportedly operable but this should be checked immediately because of the poor condition of the dam.

The 2-foot-thick foundation walls of this structure and the 15-inch cellular wall were designed to transmit the thrust from the arch to the thrust wall.

A 1-inch vertical crack was observed at the interface with the spillway, the exterior surface having been patched. This crack extends into the cellular wall, where it reduces to 3/4-inch in width. The left sidewall within the water supply intake well also has a 1-inch vertical crack. Horizontal cracks were observed on the downstream side of this structure. Displacement of the downstream wall was observed at the lowest horizontal crack; 1/4-inch displacement adjacent to the spillway and 1/2-inch displacement at the left end of the structure. Visual observations revealed that the upstream portion of the structure has rotated in a clockwise direction toward the left abutment. Minor nonstructural spalls were also observed.

The gatehouse, which is a wood framed structure, houses two wheel-operated bench stands. At the time of inspection, the waste gate was closed and the raw water intake to the town water supply system was fully opened. The bench stands and stems are well maintained. The hand wheels were chained in place in order to prevent unauthorized use.

(c) Reservoir Area (See Photo 1)

The shore of the reservoir area is generally moderately sloping woodland. It appears stable and in good condition, although there are signs of past creeping of the right bank as shown by the bowing of trees in Photo 1.

(d) Downstream Channel (See Photos 12 and 14)

The downstream channel is Charles Brown Brook, which is a narrow, rocky channel. The banks are stable and in good condition.

### 3.2 Evaluation

The dam and its appurtenant structures are generally in poor condition. The problem areas noted during the visual inspection are listed as follows:

horizontal with a high degree of efflorescence and exudation. Previously applied pneumatic mortar has spalled from the vertical face of this structure.

(4) Right Thrust Wall (See Photo 2)

With the exception of minor surface cracking and efflorescence, this structure is in good condition at the present time, with no evidence of spalls or erosion.

(5) Left Thrust Wall (See Photos 7 and 11)

With the exception of minor erosion, surface cracking, and efflorescence, this structure is in good condition at the present time. Minor erosion was observed at the water line approximately 25 feet to the left of the spillway. A concentration of 5 horizontal and 3 vertical hairline cracks was also observed at this location. Similar concentration of fine cracks and efflorescence was observed approximately 25 feet from the left abutment.

(6) Concrete Apron (See Photos 6 and 12)

The downstream concrete apron, which is approximately 20 feet long, has been subjected to considerable surface erosion.

(7) Earth Fill Embankments (See Photos 2, 6, 11, and 13)

The earth fill embankments are in fair to good condition. The left embankment shows signs of clear seepage (2 to 5 GPM) exiting over the left training wall (see Photo 6). There is light brush and tree growth on both embankments.

(b) Appurtenant Structures

Gatehouse (See Photos 4, 7, 8, 9, 10, and 12)

Visual observations of this structure included the configuration of its foundation and its relationship to the arched spillway and the left thrust wall.

### Section 3: Visual Inspection

#### 3.1 Findings

##### (a) General

The Norwich Reservoir Dam is in poor condition at the present time.

##### (b) Dam

###### (1) Spillway (See Photos 2, 4, and 12)

Observation of the downstream face of this structure revealed that it is stepped over its entire vertical height. Pneumatically applied mortar was observed to have spalled. The extent of spalling could not be determined due to sheet flow over the spillway. The crest is 3.5 feet below the thrust walls.

###### (2) Left Training Wall (See Photos 4, 5, 6, and 12)

This structure is in poor condition due to the extensive spalling, exposed reinforcing steel, cracking, efflorescence, exudation, and undermining. The cyclopean concrete has spalled over an area of approximately 20 feet long by 5 feet high by 15 inches deep, exposing reinforcing steel. There is a considerable amount of cracking associated with efflorescence from the spillway interface to the angle point in the wall 30 feet downstream. Pneumatically applied mortar within this section of wall has been subjected to severe spalling. Undermining has occurred at the base of the wall from the previously mentioned angle point to the end of the wall. In one particular instance, this undermining is in excess of 12 inches high and up to 12 inches deep.

###### (3) Right Training Wall (See Photos 2 and 3)

This structure is in poor condition due to excessive erosion, spalling, horizontal cracks, efflorescence, and exudation. Erosion over an area 3 feet wide, 4 feet high, and 12 inches deep has occurred at the interface with the spillway approximately at midheight of the wall. Cracking is extensive and is predominantly

## Section 2: Engineering Data

### 2.1 Design Data

None of the original design drawings or calculations are available for this dam. Available data includes a drawing, dated 1928 by Weston and Sampson Consulting Engineers. This drawing was accomplished for the design of repairs which were made at that time. Some inspection reports are also available. This information has been included in Appendix B of this report.

### 2.2 Construction Records

No construction records are available for this dam.

### 2.3 Operational Records

No operational records are available for this dam.

### 2.4 Evaluation of Data

#### (a) Availability

There is no detailed design or construction data available for evaluation.

#### (b) Adequacy

The lack of in-depth engineering data does not permit a definitive review. Therefore, the adequacy of the dam cannot be assessed from the standpoint of reviewing design and construction data. This assessment of the dam is based primarily on the visual inspection, past performance, and sound engineering judgment.

#### (c) Validity

Since the observations of the inspection team generally confirm the information contained in the records of the Vermont Department of Water Resources, a satisfactory evaluation for validity is indicated.

(8) Cutoff: Sheet piling under right half of dam

(9) Grout curtain: None

(h) Diversion and Regulating Tunnel

Not applicable

(i) Spillway

(1) Type: Concrete, broad crested weir arch

(2) Length of weir: 45 feet

(3) Crest elevation: 718.0 feet (NGVD)

(4) Gates: Spillways not equipped with gates

(5) Upstream channel: Reservoir

(6) Downstream channel: Charles Brown Brook

(j) Regulating Outlets

The regulating outlets at this dam consist of a 20-inch-diameter pond drain with a vertical stem steel slide gate and a 10-inch-diameter water supply main with a vertical lift gate. The invert elevation of the pond drain is approximately 700+ feet (NGVD). The invert of the supply main is unknown.

- (4) Top of dam: 700<sub>+</sub>
- (5) Test flood pool: 700<sub>+</sub>

(e) Storage (acre-feet)

- (1) Normal pool: 21.5
- (2) Flood control pool: Not applicable
- (3) Spillway crest pool: 21.5
- (4) Top of dam pool: 37.4
- (5) Test flood pool: 56

(f) Reservoir Surface (acres)

- (1) Normal pool: 2.8
- (2) Flood control pool: Not applicable
- (3) Spillway crest pool: 2.8
- (4) Test flood pool: 10<sub>+</sub>
- (5) Top of dam: 5.7

(g) Dam

- (1) Type: Concrete arch with thrust walls and earth backfill.
- (2) Length: Approximately 200 feet
- (3) Height: Approximately 28 feet
- (4) Top width: Variable
- (5) Side slopes: Upstream: vertical  
Downstream: 1 vertical to 1.5 horizontal
- (6) Zoning: Not applicable
- (7) Impervious core: Not applicable

(6) Gated Spillway Capacity at Test Flood

There are no gated spillways.

(7) Total Spillway Capacity at Test Flood

The capacity of the spillway at Test Flood elevation (725.2 feet NGVD) is 2,600 cfs.

(8) Total Project Discharge at Top of Dam

The total project discharge at top of dam elevation (721.5 feet NGVD) is 885 cfs.

(9) Total Project Discharge at Test Flood Elevation

The total project discharge at Test Flood elevation (725.2 feet NGVD) is 5,750 cfs.

(c) Elevation

- (1) Streambed at toe of dam: Approximately 694
- (2) Bottom of cutoff: Unknown
- (3) Maximum tailwater: Unknown
- (4) Normal pool: Approximately 718.0
- (5) Full flood control pool: Not applicable
- (6) Spillway crest: Approximately 718.0
- (7) Design surcharge: Unknown
- (8) Top of dam: 721.5
- (9) Test flood surcharge: 725.2

(d) Reservoir (length in feet)

- (1) Normal pool: 700<sub>+</sub>
- (2) Flood control pool: Not applicable
- (3) Spillway crest pool: 700<sub>+</sub>

(i) Normal Operating Procedure

No formal operating procedures exist for this dam. The steel waste gate is normally closed.

1.3 Pertinent Data

(a) Drainage Area

The drainage area for this dam covers 5.2 square miles. It is made up primarily of mountainous woodland.

(b) Discharge at Dam Site

(1) Outlet Works

The outlet works for this dam include a 10-inch-diameter water supply main and a 20-inch-diameter reservoir drain. The invert elevation of the water supply intake is unknown. The invert of the waste gate is estimated to be elevation 700 feet. The capacity of the waste gate with the reservoir at the top-of-dam elevation (721.5 feet NGVD) is approximately 48 cfs.

(2) Maximum Known Flood

The dam was overtopped in July 1973. No data is available on the stage or flow.

(3) Ungated Spillway Capacity at Top of Dam

The capacity of the spillway with the reservoir at top-of-dam elevation (721.5 feet NGVD) is 885 cfs.

(4) Ungated Spillway Capacity at Test Flood

The Test Flood overtops the dam by 3.7 feet. The capacity of the spillway at Test Flood elevation (725.2 feet NGVD) is 2,600 cfs.

(5) Gated Spillway Capacity at Normal Pool

There are no gated spillways.

would cause no flooding, but the failure flow would cause up to 6 feet of flooding at these houses, as well as at other housing areas further downstream. Refer to Section 5.5 for further flood information.

(e) Ownership

The dam is presently owned by the Norwich Fire District Number 1. It is overseen by the Prudential Committee. Mr. Frank Dolan is the chairman of this committee. He can be reached by telephone at (603) 643-3800. Mrs. Alice Flannery is the clerk of the Norwich Fire District Number 1. She can be reached at (802) 649-1192 at her office or (802) 649-1906 at home. The mailing address is Norwich Fire District, Water Department, Norwich, Vermont, 05055.

(f) Operator

The operation of the dam is controlled by the Norwich Fire District, Water Department, Norwich, Vermont, 05055. The chairman of the Prudential Committee, Mr. Frank Dolan, can be reached by telephone at (603) 643-3800. Mrs. Alice Flannery is the clerk of the Norwich Fire District Number 1. She can be reached at (802) 649-1192 at her office or (802) 649-1906 at home.

(g) Purpose of Dam

The present purpose of the dam is to impound water for water supply for the Norwich Fire District Number 1.

(h) Design and Construction History

The original dam at this site was constructed in 1920, according to the Corps of Engineers' "Inventory of Dams in the United States." The dam was reconstructed in 1928, with design by Weston and Sampson Consulting Engineers of Boston, Massachusetts. This work included installation of a crib wall, increasing the height of the dam by 2 feet, raising the top of the right training wall, and some foundation modifications. This work is shown on a 1928 drawing, which is reproduced as Page B-3 of this report. In July 1973, the dam was overtopped, and portions of the earthfill were washed out. Repair work in 1973 included dredging of the reservoir and restoring eroded slopes.

(4) Right Embankment

The nonoverflow section to the right of the spillway consists of a reinforced concrete thrust wall along the upstream side and a reinforced concrete retaining wall along the downstream side, with three 12-inch-thick concrete cross walls forming a crib structure which is filled with earth. The earth slope between the thrust and retaining walls is approximately 1.5 horizontal to 1 vertical. There is approximately 1 foot of fill material over the top of the cross walls. This portion of the dam extends approximately 85 feet from the right training wall to the right abutment.

(5) Gatehouse

The wood frame gatehouse rests on a 10-foot-square concrete foundation at the intersection of the left thrust wall and the left training wall. This structure houses two gate stems which control the two outlets from the reservoir. The upstream gate stem connects to a 20-inch vertical lift gate which opens to a 20-inch-diameter pond drain pipe. This daylights in the left training wall below the gatehouse. The downstream gate stem connects to a 10-inch-diameter vertical lift gate which regulates flow through a 10-inch-diameter pipe extending to the town of Norwich, where it is used for water supply.

(c) Size Classification

The dam has a maximum impoundment of 37.4 acre-feet and a height of 28 feet. According to the Corps of Engineers' Recommended Guidelines, a small size dam is one with a maximum storage between 50 and 1000 acre-feet or a height between 25 feet and 40 feet. Therefore, this dam is classified as SMALL in size, based on the latter criteria.

(d) Hazard Potential Classification

The hazard potential classification for this dam is HIGH because of the significant economic loss and potential for loss of more than a few lives downstream in the event of dam failure. There are five houses approximately 4,000 feet downstream of the dam. The prefailure flow conditions

with Blood Brook in Norwich, Vermont. The dam can be reached from Meadow Road which intersects State Route 5 in Norwich. The dam is shown on U.S.G.S., Hanover, VT-NH Quadrangle at approximate coordinates N43 43.8', W72 20.0' (see location map on Page vi). Page B-2 of Appendix B is a site plan for this dam.

(b) Description of Dam and Appurtenances

The Norwich Reservoir Dam is a concrete and earth fill structure with a concrete arch spillway, two vertical stem gates, and a water supply pipe to the town of Norwich. The overall length of the dam is 200 feet, and it is a maximum of 28 feet high.

(1) Principal Spillway (See Page B-2)

The spillway is a thin concrete arch structure with a stepped downstream training wall on either side. The radius of the arch is 100 feet, and the crest width is 2 feet. The thickness of the arch steps out at 4-foot drops so that it is 8 feet thick at the bottom. There is a concrete apron extending downstream of the dam for approximately 20 feet. The weir length is 45 feet.

(2) Training Walls

The training walls on either side of the spillway are constructed of reinforced concrete with steps down toward the downstream side. The tops of these walls are 3.5 feet above the spillway crest and the thickness varies from 28 inches to 44 inches wide.

(3) Left Abutment

The nonoverflow section to the left of the spillway consists of a reinforced concrete thrust wall which is 70 feet long from the left training wall to the left abutment. Earth fill has been placed downstream of this wall, and it is contained by the left training wall. The downstream slope is approximately 1 horizontal to 1 vertical.

# National Dam Inspection Program

## Phase I Inspection Report

### Norwich Reservoir Dam

#### Section 1: Project Information

##### 1.1 General

###### (a) Authority

Public Law 92-367, August 8, 1972, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a National Program of Dam Inspection throughout the United States. The New England Division of the Corps of Engineers has been assigned the responsibility of supervising the inspection of dams within the New England Region. Goldberg-Zoino & Associates, Inc. (GZA) has been retained by the New England Division to inspect and report on selected dams in the State of Vermont. Authorization and notice to proceed were issued to GZA under a letter of April 29, 1981, from Colonel William E. Hodgson, Jr., Corps of Engineers. Contract No. DACW 33-80-C-0055 has been assigned by the Corps of Engineers for this work.

###### (b) Purpose

(1) Perform technical inspection and evaluation of nonfederal dams to identify conditions which threaten the public safety and thus permit correction in a timely manner by nonfederal interests.

(2) Encourage and prepare the states to initiate quickly effective dam safety programs for nonfederal dams.

(3) Update, verify, and complete the National Inventory of Dams.

##### 1.2 Description of Dam

###### (a) Location

The Norwich Reservoir Dam is located on Charles Brown Brook approximately one mile upstream of its confluence

## Section 5: Evaluation of Hydraulic/Hydrologic Features

### 5.1 General

Norwich Dam is an earthfill and concrete structure used as a water supply for the Village of Norwich since the 1920's. It is a run-of-the-river project on Charles Brown Brook, with a normal pool storage capacity of 21.5 acre-feet, and a maximum storage capacity of 37.4 acre-feet. The 5.2-square-mile drainage area is mostly forested, and its terrain is mountainous.

The principal spillway consists of a thin (2 feet thick at the crest to 7 feet 6 inches thick near the base) concrete arch, 27.5 feet high, with stepped block reinforcement. Two nonoverflow sections tie into the arch and into the dam abutments. The concrete nonoverflow sections combine for a total length of about 155 feet, including a gatehouse on the left side. The principal spillway arch is about 45 feet long, giving the dam a total length of 200 feet. The elevation of the arch is 718 NGVD, and that of the nonoverflow sections is 721.5 NGVD.

Downstream of the dam, Charles Brown Brook flows through a mostly forested area parallel to Beaver Meadow Road. From the dam to the Beaver Meadow Road crossing about 4,000 feet downstream, the Brook has a fairly steep gradient; a 30-foot to 40-foot-wide channel; and steep, overgrown, side banks. One house is located in this reach, but it is well above flood danger. A town-operated recreation pool is about 3,000 feet downstream of the dam and spans the width of Charles Brown Brook.

A house is located on the right bank at the Beaver Meadow Road crossing, and there are five houses downstream of the crossing in the vicinity of the Blood Brook confluence. About 300 feet downstream of the confluence, Blood Brook flows under a side street through a small, wood-decked bridge. Two houses are within flood danger here.

Blood Brook then flows into an open reach with wide overbanks. The first part of this reach includes a grassy right overbank, and a tennis court and recreation area on the left bank. At the downstream end of this section is a housing development on the right bank, with about six houses near the streambank height. The next part of this reach includes a church on the left bank and ends with the crossing of Beaver Meadow Road.

## 5.2 Design Data

Original design plans and hydrologic analysis for this dam are unavailable. Restoration plans by Weston and Sampson (1928) show an old retaining wall (replaced) and an old thrust wall one foot lower than present. The old nonoverflow sections were raised, apparently to provide more flood protection for the structure.

## 5.3 Experience Data

Detailed experience data for the dam are unavailable, but a 1973 event apparently overtopped the dam and eroded some of the earth backfill. New fill and some minor repairs have since restored the dam to preflood conditions.

## 5.4 Test Flood Analysis

The impoundment of less than 1,000 acre-feet and height of less than 40 feet classify this dam as a SMALL structure. The appropriate hazard class is HIGH, due the potential for loss of more than a few lives at more than ten residential houses within the flood hazard area. The Test Flood for a dam classified as small with a high hazard rating is between one-half of the Probable Maximum Flood (PMF) and the PMF. Since the storage capacity of 22 acre-feet is at the lower end of the small size classification, the one-half PMF has been adopted as the Test Flood. The one-half PMF for this dam is 1,100 cfs per square mile, or 5,750 cfs.

The small size of the reservoir would not significantly attenuate a Test Flood of this magnitude. The routed peak Test Flood outflow would, therefore, be 5,750 cfs, which would create a water surface elevation at the dam of 725.2 NGVD, 3.7 feet above the nonoverflow sections. The normal spillway capacity of 890 cfs is only 15% of the peak Test Flood outflow.

## 5.5 Dam Failure Analysis

The peak downstream flows that would result from the failure of Norwich Dam are estimated using the procedure suggested in "Rule of Thumb Guidelines for Estimating Downstream Failure Hydrographs." The failure is assumed to occur at the top of the nonoverflow section (721.5 feet NGVD). The outflow prior to dam failure would be 890 cfs, creating a tailwater of about 2.4 feet in the channel downstream of the dam.

For an assumed breach width equal to 40% of the dam width at half-height, the gap in the embankment due to failure would be about 50 feet. The resulting peak failure outflow would be 13,000 cfs, which would increase the tailwater stage from 2.4 feet to 11.1 feet above the streambed.

The peak failure outflow would attenuate to a peak of about 6,000 cfs at the Beaver Meadow Road crossing, about 4,000 feet downstream. This peak flow would create a stage of about 6.2 feet over the road, enough to cause a serious flood hazard for the house located on the right bank. The five houses in the reach between the Beaver Meadow Brook crossing and a wooden-decked bridge on Blood Brook would also experience severe flooding.

The residential housing site downstream of the bridge would be subject to a stage of about 6.3 feet above the channel bottom of Blood Brook and about 2.3 feet above the streambanks. The attenuated peak flow is 3,900 cfs. The potential for loss of life exists here, as well as at the other sites discussed previously.

At the downstream crossing of Beaver Meadow Road, the peak flow would have attenuated to 3,200 cfs with a stage of about 5.8 feet. The church between the road crossing and the housing site would probably receive damage due to the failure wave and also due to backwater from the Beaver Meadow crossing. Damage will probably be incurred at this crossing and at each of the four other crossings downstream, but residential housing is located above damaging river stages.

Due to the risk of loss of more than a few lives in the event of a dam failure, the appropriate hazard classification for this dam is HIGH. The downstream impacts of a dam failure are summarized in the chart on the following page.

# DOWNSTREAM IMPACT OF THE FAILURE OF NORWICH DAM

<u>Location</u>	<u>Distance Downstream of Dam (ft.)</u>	<u>Number of Structures</u>	<u>Level Above Stream (ft.)</u>	<u>Flow and Stage</u>		<u>Comments</u>
				<u>Before Failure</u>	<u>After Failure</u>	
Just below Dam	-	-	-	885 cfs 2.4 ft.	12985 cfs 11.1 ft.	
House at Beaver Meadow Road Crossing	4000	1 house	7.5-8	885 cfs ≈7.5 ft.	6000 cfs 13.7 ft.	danger of loss of life, structure damage
Beaver Meadow Road Crossing	4000	16' W by 6' H culvert	-	885 cfs ≈7.5 ft.	6000 cfs 13.7 ft.	damage possible
Houses downstream	4100-4200	5 houses	8	885 cfs 7.5 ft.	6000 cfs 13-14 ft.	damage, danger of loss of life
Upstream end of second reach	4200		-	1765 cfs 4.5 ft.	6880 cfs 7.6 ft.	
First section of second reach	6700	6 houses	4-5	1765 cfs 4.5 ft.	3990 cfs 6.3 ft.	damage, danger of loss of life
Downstream Beaver Meadow Road Crossing	8800	church	4-5	1765 cfs 4.5 ft.	3200 cfs 5.8 ft.	backwater flooding from culvert

## Section 6: Structural Stability

### 6.1 Evaluation of Structural Stability

#### (a) General

The Norwich Reservoir Dam is in poor condition at the present time.

#### (1) Left Training Wall

The high degree of surface erosion (in excess of 12 inches) of the cyclopean concrete dramatically reduces the effective thickness. Visual observations indicate that much of the cobble aggregate is 6 inches to 8 inches in diameter and seriously unbonded. This training wall forms a buttress to the gatehouse foundation which has been subjected to distress. Partial failure of this wall could conceivably cause a domino effect, resulting in potential failure of the dam.

#### (2) Gatehouse

The foundation of this structure has been subjected to multiple vertical cracks with associated rotation in a clockwise direction toward the left abutment. The downstream portion of this wall has sheared and has been displaced in the downstream direction. The structural stability of this structure is being jeopardized.

#### (3) Right Training Wall

The high degree of horizontal cracking and erosion at the interface with the spillway jeopardizes this structure.

#### (4) Spillway

There is evidence of spalling of the pneumatically applied mortar on the downstream face of this structure. Based upon the condition of the surrounding components, as discussed in the previous paragraphs, it is recommended that this structure be thoroughly investigated under low flow conditions.

(5) Design and Construction Records

No plans or calculations of value to a stability assessment are available for this dam.

6.2 Design and Construction Data

No records of structural stability analyses are available for this dam.

6.3 Post Construction Changes

The dam was constructed in 1918. The dam was modified and repaired in 1928, including raising the crest by 2 feet. Repairs were made to the embankments in 1973, after the dam was overtopped.

6.4 Seismic Stability

The dam is located in seismic zone No. 2 and, in accordance with the recommended Phase I guidelines, does not warrant seismic analysis.

## Section 7: Assessment, Recommendations, and Remedial Measures

### 7.1 Dam Assessment

#### (a) Condition

The Norwich Reservoir Dam is in poor condition at the present time. The left training wall and gatehouse should be reconstructed. The right training wall should be repaired.

#### (b) Adequacy of Information

The lack of in-depth engineering data precludes a definitive review. Therefore, the adequacy of the dam cannot be assessed from the standpoint of reviewing design and construction data. This assessment is based primarily on the visual inspection, past performance, and sound engineering judgment.

#### (c) Urgency

The engineering studies and improvements described herein should be implemented by the owner within one year of receipt of this Phase 1 Inspection Report except as noted in Paragraphs 7.3 a and b.

### 7.2 Recommendations

It is recommended that the services of a qualified registered professional engineer be retained to:

- (a) Conduct a detailed hydraulic and hydrologic study to further define the need for and means to increase the project discharge capacity and the ability of the dam to withstand overtopping.
- (b) Investigate the source of the seepage through the left embankment and make recommendations for remedial measures.
- (c) Investigate the structural stability of the left training wall, the gatehouse foundation, and the spillway.
- (d) Investigate the condition of the right training wall.

(e) Prepare plans for the renovation, repair, or replacement of the gatehouse foundation, the spillway, and the left and right training walls.

(f) Develop a method to remove all trees (including the roots) from the embankments, and backfill the resulting voids with suitable compacted material.

The owner should implement the findings of the above engineering studies.

### 7.3 Remedial Measures

It is recommended that the following remedial measures be undertaken by the owner:

(a) Upon receipt of report immediately check the operability of the outlet works through their full range.

(b) Upon receipt of report immediately develop a plan for surveillance of the dam flood periods and a formal, written system for warning downstream residents and appropriate officials in the event of an emergency.

(c) Remove all brush from the embankments.

(d) Implement a program of annual technical inspections of the dam and its appurtenances, including operation of all outlet works.

(e) Implement and intensify a program of diligent and periodic maintenance.

### 7.4 Alternatives

Since this dam is scheduled to be taken out of service as a water supply dam in the near future, a possible alternative to the above measure would be removal of the dam under the direction of a qualified registered professional engineer.

APPENDIX A  
VISUAL CHECKLIST WITH COMMENTS

### Inspection Team Organization

DATE: May 14, 1981

PROJECT: VT00157  
Norwich Reservoir Dam  
Norwich, Vermont  
VTDWR No. 146.1

WEATHER: Sunny, warm

#### INSPECTION TEAM:

Nicholas A. Campagna	Goldberg-Zoino & Assoc.	Team Captain
William S. Zoino	GZA	Soils
Jeffrey M. Hardin	GZA	Soils
Paul Razgha	Andrew Christo Engineers	Structures
Carl Razgha	ACE	Structures
Richard Laramie	Camp Dresser & McKee	Hydrology

Owner's Representative Present - Mr. Commery Cook

## CHECKLIST FOR VISUAL INSPECTION

AREA EVALUATED	BY	CONDITIONS AND REMARKS
<u>DAM EMBANKMENT</u>		
Crest Elevation	NAC	721.5 feet
Current Pool Elevation		718.0 feet
Maximum Impoundment to Date		Unknown
Surface Cracks		None noted
Pavement Condition		Not applicable
Movement or Settlement of Crest		None noted
Lateral Movement		None noted
Vertical Alignment		Good
Horizontal Alignment		Good
Condition at Abutment and at Concrete Structures		Good
Indications of Movement of Structural Items on Slopes		None
Trespassing on Slopes		None
Vegetation on Slopes		Small trees and brush growing on both embankments should be mown
Sloughing or Erosion of Slopes or Abutments	NAC	None

## CHECKLIST FOR VISUAL INSPECTION

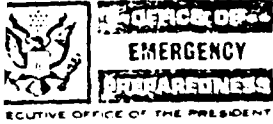
AREA EVALUATED	BY	CONDITIONS AND REMARKS
Rock Slope Protection - Riprap Failures	NAC	None
Unusual Movement or Cracking at or near Toes		None
Unusual Embankment or Downstream Seepage		Approximately 2 to 5 GPM seepage from left embankment over left training wall
Piping or Boils		None
Foundation Design Features		Unknown, none noted
Toe Drains		Unknown, none noted
Instrumentation System	NAC	None noted
<u>LEFT TRAINING WALL</u>		
Condition of Concrete	CR	Poor
Spalling		20 feet long, up to 5 feet high, and up to 15 inches deep, severe spalling of pneumatically applied mortar
Erosion		Entire length of return wall in excess of 12 inches high and 12 inches deep
Cracking	CR	Where not spalled, cracks over 50 percent of balance of wall

## CHECKLIST FOR VISUAL INSPECTION

AREA EVALUATED	BY	CONDITIONS AND REMARKS
Efflorescence	PR	At cracks
Exudation		At cracks
Visible Reinforcing		At spalled areas
Rusting or Staining of Concrete		At perimeter of spalled areas
Seepage		Minor at return wall
<u>RIGHT TRAINING WALL</u>		
Condition of Concrete		Poor
Spalling		Pneumatically applied mortar spalled
Erosion		3 feet wide, 4 feet high, and 12 inches deep at interface with spillway
Cracking		Excessive defined horizontal cracks
Efflorescence		At all cracks
Exudation		Excessive at effloresced areas
Visible Reinforcing		None noted
Seepage	PR	None noted

## CHECKLIST FOR VISUAL INSPECTION

AREA EVALUATED	BY	CONDITIONS AND REMARKS
<u>RIGHT THRUST WALL</u>	PR	
Condition of Concrete		Good
Spalling		None noted
Erosion		None noted
Cracking		Minor
Efflorescence		Minor
Exudation		None noted
Visible Reinforcing		None noted
Rusting or Staining of Concrete	PR	None noted
<u>LEFT THRUST WALL</u>		
Condition of Concrete		Fair
Spalling		None noted
Erosion		Minor at waterline 25 feet to left of spillway
Cracking		Concentration of fine horizontal and vertical cracks, 25 feet to left of spillway and 25 feet from left abutment



# DAMAGE SURVEY REPORT

(Under Public Law 606, 91st Congress)

APPLICANT (State Agency, County, City, Irrigation District, etc.) <b>Town of Norwich</b>		2. DISASTER DECLARATION DATE <b>6 July 1973</b>
STATE <b>Vermont</b>	4. COUNTY <b>Windsor</b>	5. INSPECTION DATE <b>18 July 1973</b>
6. WORK CATEGORY (SEE DEFINITIONS)		7. MAP OR PHOTO REFERENCE NO. <b>USGS Hanover VT-NH Quad</b>
EMERGENCY <input type="checkbox"/> A <input type="checkbox"/> B <input type="checkbox"/> C-1 <input checked="" type="checkbox"/> D-1 <input type="checkbox"/> E-1 <input type="checkbox"/> F-1 PERMANENT <input type="checkbox"/> C-2 <input type="checkbox"/> D-2 <input type="checkbox"/> E-2 <input type="checkbox"/> F-2 <input type="checkbox"/> G		8. WORK TO BE ACCOMPLISHED BY: <input checked="" type="checkbox"/> a. Contract <input type="checkbox"/> b. Force Account
LOCATION AND DESCRIPTION OF DAMAGED FACILITIES <b>Water supply dam on Charles Brown Brook about 2 miles north west of village of Norwich. Metric Coord: N4845000 E 715000. Dam is earth and concrete structure.</b>		10. PERCENTAGE OF WORK COMPLETED TO DATE <b>0</b>
1. DESCRIPTION OF DAMAGE <b>Overtopping of dam washed out portions of earth fill supporting non-overflow concrete portions of dam and displaced section of concrete apron for spillway.</b>		
2. PROPOSED WORK <b>Replace lost earth fill to left of spillway with uncompacted coarse gravel fill to original grades. Purpose is to support concrete wall and provide safe access to gate house</b>		

## 13. SUMMARY OF ESTIMATE

QUANTITY a.	UNIT b.	MATERIAL AND/OR DESCRIPTION c.	UNIT PRICE d.	COST e.
200	cubic Yards	Uncompacted Coarse Gravel Fill	\$ 4.00	\$ 800.00
TOTAL ESTIMATED COST				\$ 800.00

4. INSURANCE COVERAGE ☐ YES ☒ NO AMOUNT \_\_\_\_\_

## 15. RECOMMENDATION

☒ a. ELIGIBLE ☐ b. INELIGIBLE (Explain Separately) c. FEDERAL INSPECTOR (Signature & Agency Name) **Henry H. Baker, Jr. - USA Army Engrs - NED** d. DATE **18 July 1973**

## 16. CONCURRENCES

a. YES <input checked="" type="checkbox"/> b. NO <input type="checkbox"/>	c. STATE INSPECTOR (Signature) <b>Ronald H. Smith</b>	d. AGENCY OR OFFICE <b>Dep't. of Water Res.</b>	e. DATE <b>7-18-73</b>
f. YES <input checked="" type="checkbox"/> g. NO <input type="checkbox"/>	c. REPRESENTATIVE OF APPLICANT (Signature) <b>W. H. Smith</b>		d. DATE <b>7/18/73</b>

## (3) Fill:

(a) Compacted earthfill - right abutment 300 cy  
 left abutment 300 cy.

$$600 \text{ cy} @ \$4.00/\text{cy} = \$2400$$

(b) Topsoil & seed 50 cy @ \$10.00 = 500

(c) Crushed stone filter (apron foundation)

2' x 43' x 15' Say 35 cy @ \$6 = 210 not in DSR

Sub-Total \$2900

## (4) Reinforced Concrete Apron:

12' x 43' x 1' Say 20 cy @ \$200/cy = \$4,000

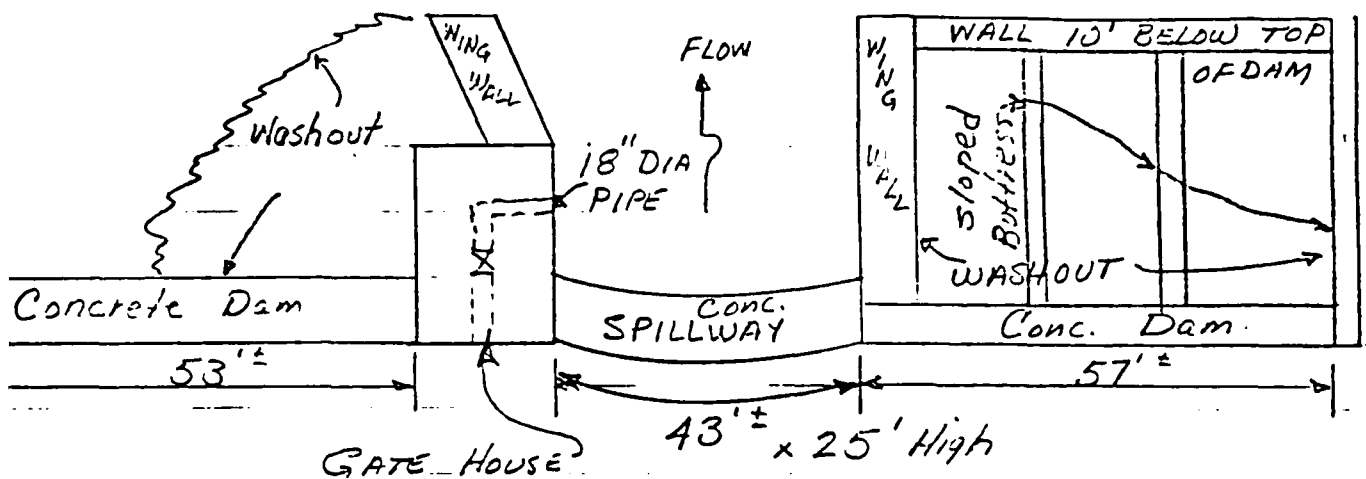
ITEMS:	(1)	\$ 2500
	(2)	2250
	(3)	2900
	(4)	<u>4000</u>
Sub Total		11,650

(5) Control & Diversion of Water  
Lump Sum Estimate:

$$\begin{array}{r}
 2,500 \\
 \hline
 \$14,150 \\
 \text{Engr. Fee} = 10\% = \underline{1,415} \\
 \hline
 \$15,565
 \end{array}$$

16 JULY 73

NORWICH DAM & RESERVOIR @  
CHARLES BROWN BROOK



BACK UP DATA FOR ESTIMATE

- 1.) Access to Right Abutment - Haul Road (1000' x 20')
- |   |   |                |
|---|---|----------------|
| Clearing 1000' x 20' = 1/2 Acre @ 1000/A    | = | \$ 500         |
| Grading 1000 x 20 x 3 ≈ 2500 c.y. @ 0.50/cy | = | 1250           |
| Fill 60 x 3 x 21 Say 200 cy @ 2.50          | = | 500            |
| Culvert Pipe 24" Dia 25 LF @ 11/FT          | = | 275            |
|   |   | <u>\$ 2475</u> |
|   |   | Say \$ 2500    |

2.) Excavation:

- |  |                |
|--|----------------|
| Removed disturbed Fill & debris        | 300 cy         |
| Remove emergency Fill (30' x 30' x 6') | ≈ 200 cy.      |
| Remove concrete slabs (10' x 4' x 1')  | ≈ 20 cy.       |
| Total Excavation 500 cy @ \$ 2.50/cy   | = \$ 1250      |
| Remove Conc. slabs 20 cy @ 50.00/cy    | = 1000         |
|  | <u>\$ 2250</u> |



**OFFICE OF  
EMERGENCY  
PREPAREDNESS**  
EXECUTIVE OFFICE OF THE PRESIDENT

# DAMAGE SURVEY REPORT

(Under Public Law 606, 91st Congress)

1. APPLICANT (State Agency, County, City, Irrigation District, etc.) <b>Town of Norwich</b>		2. DISASTER DECLARATION DATE <b>6 July 1973</b>
3. STATE <b>Vermont</b>	4. COUNTY <b>Windsor</b>	5. INSPECTION DATE <b>18 July 1973</b>
6. WORK CATEGORY (SEE DEFINITIONS)		7. MAP OR PHOTO REFERENCE NO. <b>USGS Historic VT-NH Quad.</b>
a. EMERGENCY <input type="checkbox"/> A <input type="checkbox"/> B <input type="checkbox"/> C-1 <input type="checkbox"/> D-1 <input type="checkbox"/> E-1 <input type="checkbox"/> F-1	c. ITEM NO. <b>1-5</b>	8. WORK TO BE ACCOMPLISHED BY: <input checked="" type="checkbox"/> a. Contract <input type="checkbox"/> b. Force Account
b. PERMANENT <input type="checkbox"/> C-2 <input checked="" type="checkbox"/> D-2 <input type="checkbox"/> E-2 <input type="checkbox"/> F-2 <input type="checkbox"/> G	9. LOCATION AND DESCRIPTION OF DAMAGED FACILITIES <b>Water supply dam on Charles Brown Brook about 2 miles northwest of village of Norwich. Metric coords. N 4845000 E 715000. Dam is earth and concrete structure.</b>	
10. PERCENTAGE OF WORK COMPLETED TO DATE <b>0</b>		
11. DESCRIPTION OF DAMAGE <b>Overtopping of dam washed out portions of earth fill supporting non-overflow concrete portions of dam and displaced section of concrete apron for spillway.</b>		
12. PROPOSED WORK <b>Replace lost fill and displaced apron slab to restore dam to pre-flood condition. It is recommended, however, that grant-in-lieu be considered as spillway capacity of restored structure will not be adequate to safely pass a flood of magnitude equal to that which caused reported damage.</b>		

## 13. SUMMARY OF ESTIMATE

QUANTITY a.	UNIT b.	MATERIAL AND/OR DESCRIPTION c.	UNIT PRICE d.	COST e.
1	Job	1000' Haul Road	Lump Sum	\$ 2,500.00
1	Job	Control & Diversion of Water	Lump Sum	2,500.00
500	Cubic Yards	Earth Excavation	\$ 2.50	1,250.00
20	Cubic Yards	Removal Concrete Slabs	50.00	1,000.00
50	Cubic Yards	Topsoil, Sanded	10.00	500.00
600	Cubic Yards	Compacted Earth Fill	4.00	2,400.00
20	Cubic Yards	Reinforced Concrete	200.00	4,000.00
1	Job	Engineering Fee	Lump Sum	1,415.00
TOTAL ESTIMATED COST				\$ 15,565.00

14. INSURANCE COVERAGE	<input type="checkbox"/> YES <input checked="" type="checkbox"/> NO	AMOUNT _____
------------------------	---	--------------

## 15. RECOMMENDATION

<input checked="" type="checkbox"/> a. ELIGIBLE <input type="checkbox"/> b. INELIGIBLE (Explain Separately)	c. FEDERAL INSPECTOR (Signature & Agency Name) <b>Henry H. Baker, Jr. US Army Engineers AFED</b>	d. DATE <b>18 July 73</b>
---	---	------------------------------

## 16. CONCURRENCES

<input checked="" type="checkbox"/> a. YES <input type="checkbox"/> b. NO	c. STATE INSPECTOR (Signature) <b>Daniel H. Spies</b>	d. AGENCY OR OFFICE <b>Dept. of Water Resources</b>	e. DATE <b>7-18-73</b>
<input checked="" type="checkbox"/> a. YES <input type="checkbox"/> b. NO	c. REPRESENTATIVE OF APPLICANT (Signature) <b>W.C. [Signature]</b>	d. DATE <b>7/18/73</b>	

11/2/74  
aw

INSPECTION REPORT  
ON  
Norwich Water Supply Dam

1. Date of inspection 4/16/52 2. Water conditions overflowing crest

GENERAL DATA:

3. Location of dam Charles Brown Br. ; Town of Norwich  
4. Owner and operator Norwich Water Supply Co.  
5. Characteristic features of dam concrete spillway section  
(30' long x 25' high) with earth wings each about 50' long  
6. Other related data surface area = 7 acres (estimated)  
volume = 2,500,000 cu. ft. (estimated) D.A. = 4 sq. mi

OBSERVATIONS:

7. Condition of structure embankment - head wall shows  
deep surface erosion at water line. - fill is a sandy  
material having little compaction but stable steep slopes.  
Concrete - spillway indicates surface scour, also  
end walls show spalling  
8. Condition of equipment satisfactory  
9. Operation free crest discharge other wise water  
diverted thru pipe line  
10. Maintenance satisfactory

REMARKS:

Concrete section is on earth foundation. Note  
condition at next visit at time of low water

Inspected by SMA

July 21, 1978

At the north end of the spillway is the gate house. There is severe cracking of the foundation walls. The cracks should be grouted immediately to maintain their integrity.

The dam does not show any signs of imminent collapse, but it is beginning to deteriorate and lack of corrective action will most likely allow the rate of deterioration to increase.

The Prudential Committee asked the writer to express some thoughts on the viability of installing flashboards. Due primarily to insufficient spillway capacity, the writer suggested the flashboards would not be a practical solution to increasing the water supply. Because they would have to be set to trip with a relatively small rise in water level, there would be a constant maintenance of replacing pins and boards. If automatic gates such as bascule gates were installed, they would be expensive to begin with, need to be heated in cold months to prevent icing and may not be adaptable because of the curved nature of the spillway anyhow. Fabridam is a possibility, but again is very expensive and may be subject to puncture by large debris.

v1



# State of Vermont

## AGENCY OF ENVIRONMENTAL CONSERVATION

Department of Fish and Game  
Department of Forests, Parks, and Recreation  
Department of Water Resources  
Environmental Board  
Division of Environmental Engineering  
Division of Environmental Protection  
Natural Resources Conservation Council

Montpelier, Vermont 05602  
Department of Water Resources

### WATER QUALITY DIVISION

July 21, 1978

#### M E M O R A N D U M

To: File

From: Donald H. Spies

Subject: Norwich Water Supply Dam - Norwich

At the request of the Prudential Committee, the writer went to Norwich on March 29, 1978 to inspect the water supply dam. However, due to snow and ice cover, it was not possible to make an inspection. It was agreed the writer would return in the summer at a time when little or no water was flowing over the spillway.

The writer returned on July 12, 1978 and was able to make an inspection. Basically, the dam consists of a concrete gravity spillway with concrete walls extending to each abutment. These walls are the upstream face of the dam. In addition, there are curving concrete gravity walls which form the sidewalls for the spillway. There is a concrete apron extending from the base of the spillway to the downstream end of the side walls. The downstream side is composed of concrete walled bins which have been backfilled with earth.

The spillway and its side walls all show varying signs of deterioration. The north side wall and the upper half of the spillway have serious spalling. Both side walls are leaching calcium and have numerous minor cracks. Some seepage was noted at the downstream end of the north wall, but no determination was made as to whether the water came from the reservoir or from the hillside. There is minor undermining at the downstream end of the apron. It does not currently present any danger to the spillway, but some sort of cutoff wall should be constructed to protect the apron.

No serious problems were detected in the earth, though some brush and tree cutting is needed. The south wall appeared sound, however, spalling at the water line was noted near the north abutment of the north wall.

## FILE COPY

ROUTING		
GENERAL		
TO	NOTED	DATE
DHS DLC	<i>[Signature]</i>	7-24-78
SUSPEND TO		
FILE		

WATER QUALITY DIVISION

802/828-2761

July 24, 1978

*Norwich Reservoir -  
Norwich*

Mr. Robert Huck, Chairman  
Prudential Committee  
Norwich Fire District  
Norwich, VT 05055

Dear Mr. Huck:

This is to transmit my report on the inspection of the water supply dam on Charles Brown Brook. For your use I am enclosing three copies of the report.

I recommend the District retain a qualified consulting engineer to develop a detailed scope of work, cost estimates, and plans, specifications and other contract documents.

I made an inquiry into the question of trees around the reservoir and their effect on water quality. I was told that leaves and needles falling into the water can have an adverse effect on water quality once the material starts to decay. It is generally recommended the shoreline be kept clear of trees and brush. It should be noted that cutting the perimeter trees will not totally solve the problem because material already in the water will continue to decay and some new material will be brought in by the brook.

Sincerely yours,

Donald H. Spies  
Environmental Engineer

v1

cc: Thomas Nesbitt, Environmental Engineering  
Douglas Zorzie, Water Supply Division, Department of Health

Enclosures

Corps of Engineers ID # VT00157  
State of Vermont  
(Dept. of Water Resources) ID # 146-1

NORWICH RES DAM

12/4/80  
MMS

$$DA = 4 \frac{1}{2} \text{ mi}^2 \quad SA = 3.5^2 A \text{ (acre count)}$$

$$Q = 160 \text{ cfs} \quad sh = 25' \quad H = 25'$$

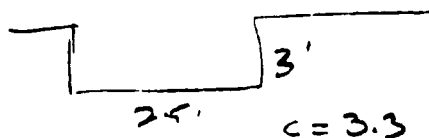
PG RE

USGS 46-C VT 7420 11-162

Storage Nur

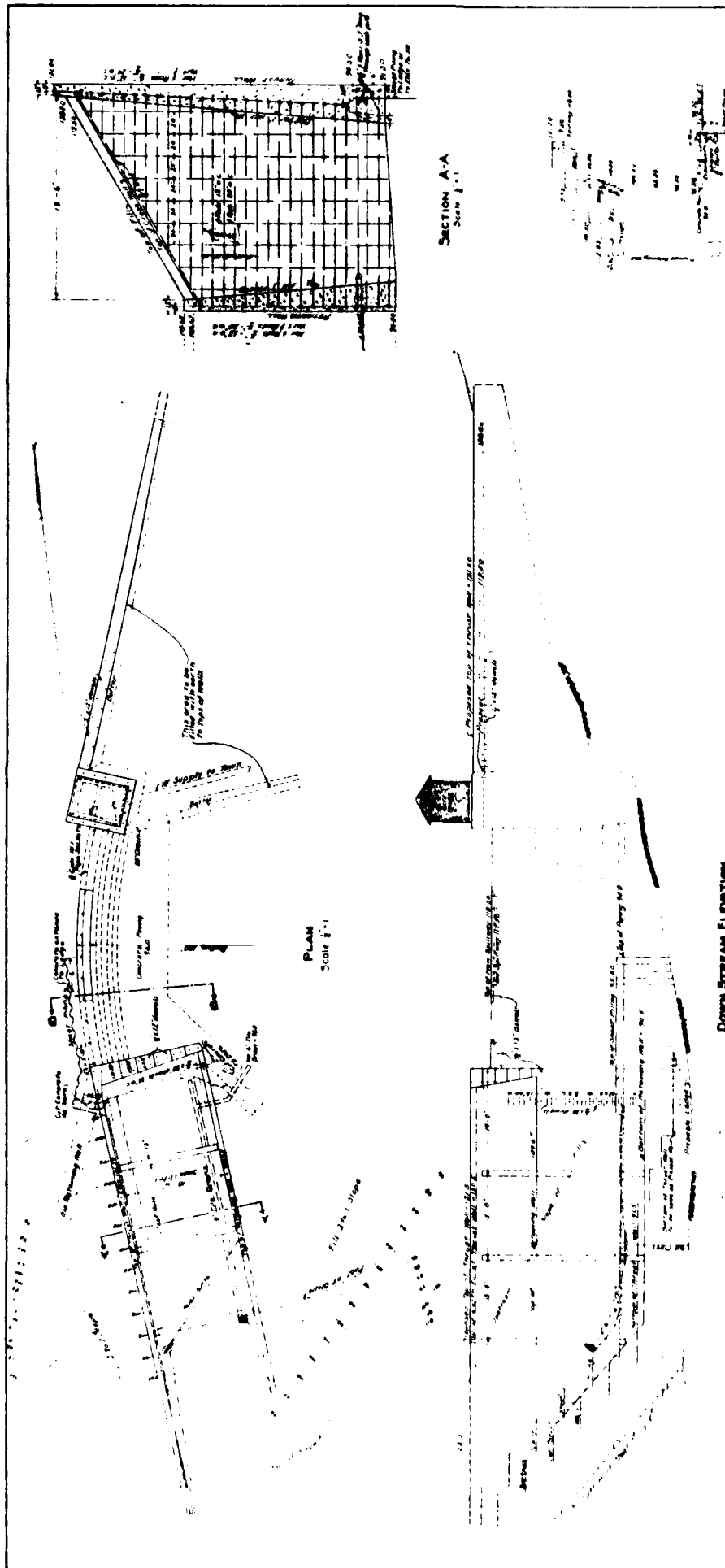
$$3.5 A \times .4 \times 25' = 35 AC \quad \underline{35}$$

$$35 + 3 \text{ (Crest)} = 47 AF \quad \underline{50}$$



$$Q = (3.3)(25)(3)^{1.5} = 429 \quad \underline{430}$$

Must be field checked  
again

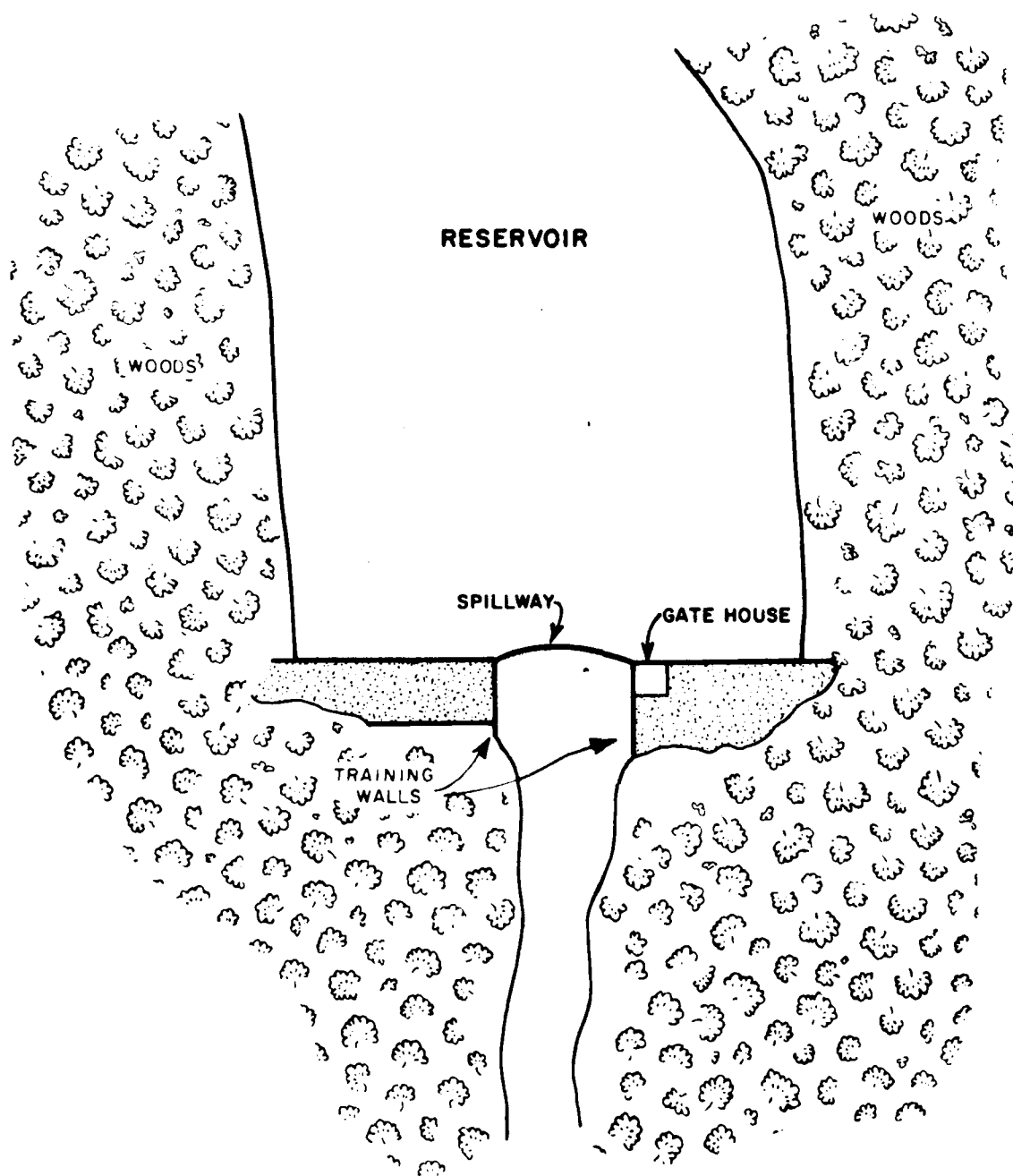


NORWICH WATER SUPPLY COMPANY, INC.  
 NORWICH, VERMONT  
 RESTORING CONCRETE DAM  
 ON BEAVER MEADOW BROOK

SCALES AS NOTED

MAY 1925

WESTON & SAMMON



GOLDBERG ZOINO & ASSOCIATES, INC.  
GEOTECHNICAL-GEOMYDROLOGICAL CONSULTANTS  
NEWTON UPPER FALLS, MASSACHUSETTS

U.S. ARMY ENGINEER DIV. NEW ENGLAND  
CORPS OF ENGINEERS  
WALTHAM, MASSACHUSETTS

NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

## SITE PLAN

NORWICH RESERVOIR DAM

NORWICH VT.

SCALE 1" = 60'

DATE JUNE 1981

FILE No 2605

APPENDIX B  
ENGINEERING DATA

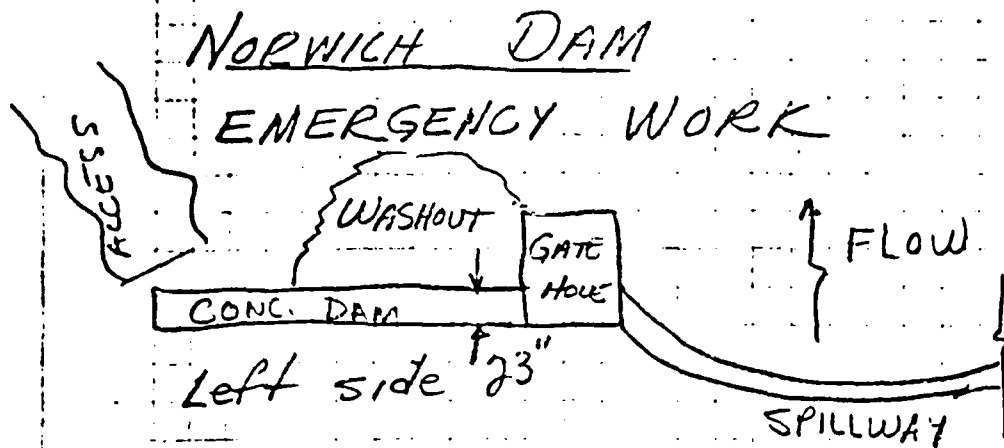
## CHECKLIST FOR VISUAL INSPECTION

AREA EVALUATED	BY	CONDITIONS AND REMARKS
<u>CONCRETE APRON</u> Condition of Concrete <u>RESERVOIR AREA</u> Slopes	PR  NAL	Surface erosion   Generally good, bowing trees are a sign of creep, does not appear significant

## CHECKLIST FOR VISUAL INSPECTION

AREA EVALUATED	BY	CONDITIONS AND REMARKS
<u>GATEHOUSE</u>	PR	
Condition of Concrete		Poor
Spalling		Minor
Erosion		None noted
Cracking		1-inch vertical crack at interface with spillway, extending to 3/4-inch vertical crack through cellular wall and 1 inch vertical crack on left wall. Horizontal crack on downstream wall. Foundation displaced average of 3/8 inch downstream. Upstream portion of foundation rotated clockwise from spillway to left abutment
Efflorescence		Minor
Visible Reinforcing		None noted
Rusting or Staining of Concrete		None noted
Superstructure		Fair
Bench Stands and Operating Mechanism	PR	Good

SUBJECT \_\_\_\_\_  
COMPUTATION \_\_\_\_\_  
COMPUTED BY \_\_\_\_\_ CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_



WASHOUT =  $30' \times 30' \times 6" \approx 200$  cubic yards

Replace washout immediately to provide  
access to Gate House & insure stability  
of 23" Concrete wall.



OFFICE OF  
EMERGENCY  
PREPAREDNESS  
EXECUTIVE OFFICE OF THE PRESIDENT

# REPORT OF FINAL COMPLETED WORK INSPECTION

(Under Public Law 606, 91st Congress)

DISTRIBUTION - Send two completed copies to OEP regional office and one completed copy to State

TO: <b>OFFICE OF EMERGENCY PREPAREDNESS</b> REGION <u>1</u>		FROM (Agency and/or Bureau and Location) <b>CORPS OF ENG N.E.D.</b>	
1. APPLICANT <b>NORWICH FIRE DISTRICT</b>		2. DATE OF THIS REPORT <b>4 JAN 74</b>	
3. PROJECT APPLICATION NO. <b>OEP 397 DR- 95</b>	4. DATE OF INITIAL DAMAGE SURVEY <b>19 JUL 74</b>	5. ORIGINAL ESTIMATED COST <b>\$ 800.00</b>	6. WORK ACCOMPLISHED BY <input checked="" type="checkbox"/> a. Contract <input type="checkbox"/> b. Force Account
7. INSPECTION MADE BY (Names and titles of inspecting officials) <b>J. DINEWALL C OF E N.E.D.</b> <b>R. TEERI VT. D.W.R.</b>		8. 4. DATE OF FINAL INSPECTION <b>4 JAN 74</b> b. IS ACTIVITY IN OPERATION? <input checked="" type="checkbox"/> YES <input type="checkbox"/> NO	
9. WORK CATEGORY AND ITEM NO.(S). (Identify individual items of work per category which have been completed in accordance with the approved project application and the completion date for each.) <b>D-1-1 REF #4 EST. COST = 800 ACT. COST. \$ 760.00</b>			
10. REMARKS (Explain all deviations or omissions from approved work. Use additional sheets if necessary) <b>WORK DONE WITHIN SCOPE DESCRIBED ON D.S.R.</b> <b>COSTS APPEAR CONSISTANT WITH WORK ACCOMPLISHED.</b>			

## CERTIFICATION

THE ABOVE ITEM(S) IN THE PROJECT APPLICATION FOR THE CATEGORY OF WORK SHOWN HAS BEEN VISUALLY INSPECTED AND CERTIFICATION IS HEREBY MADE THAT THE WORK HAS BEEN COMPLETED AS APPROVED THEREIN, EXCEPT AS NOTED ABOVE.	
STATE INSPECTING OFFICIAL (Signature and title) <b>Robert S Teeri Water Resources</b>	DATE <b>4 Jan 74</b>
LOCAL INSPECTING OFFICIAL (Signature and title) <b>X W.D. Ridd, Pres Norwich Fire Dist.</b>	DATE <b>1/4/74</b>
FEDERAL AGENCY CONCURRENCE	
REVIEWING OFFICIAL (Signature) <b>John C Dinewall</b>	TITLE <b>Corps of Engineers - N.E.D.</b>
NAME OF AGENCY (IF FEDERAL INSPECTOR NOT PRESENT DURING FINAL INSPECTION PLEASE EXPLAIN)	DATE <b>4 Jan '74</b>



**OFFICE OF  
EMERGENCY  
PREPAREDNESS**  
EXECUTIVE OFFICE OF THE PRESIDENT

# REPORT OF FINAL COMPLETED WORK INSPECTION

(Under Public Law 606, 91st Congress)

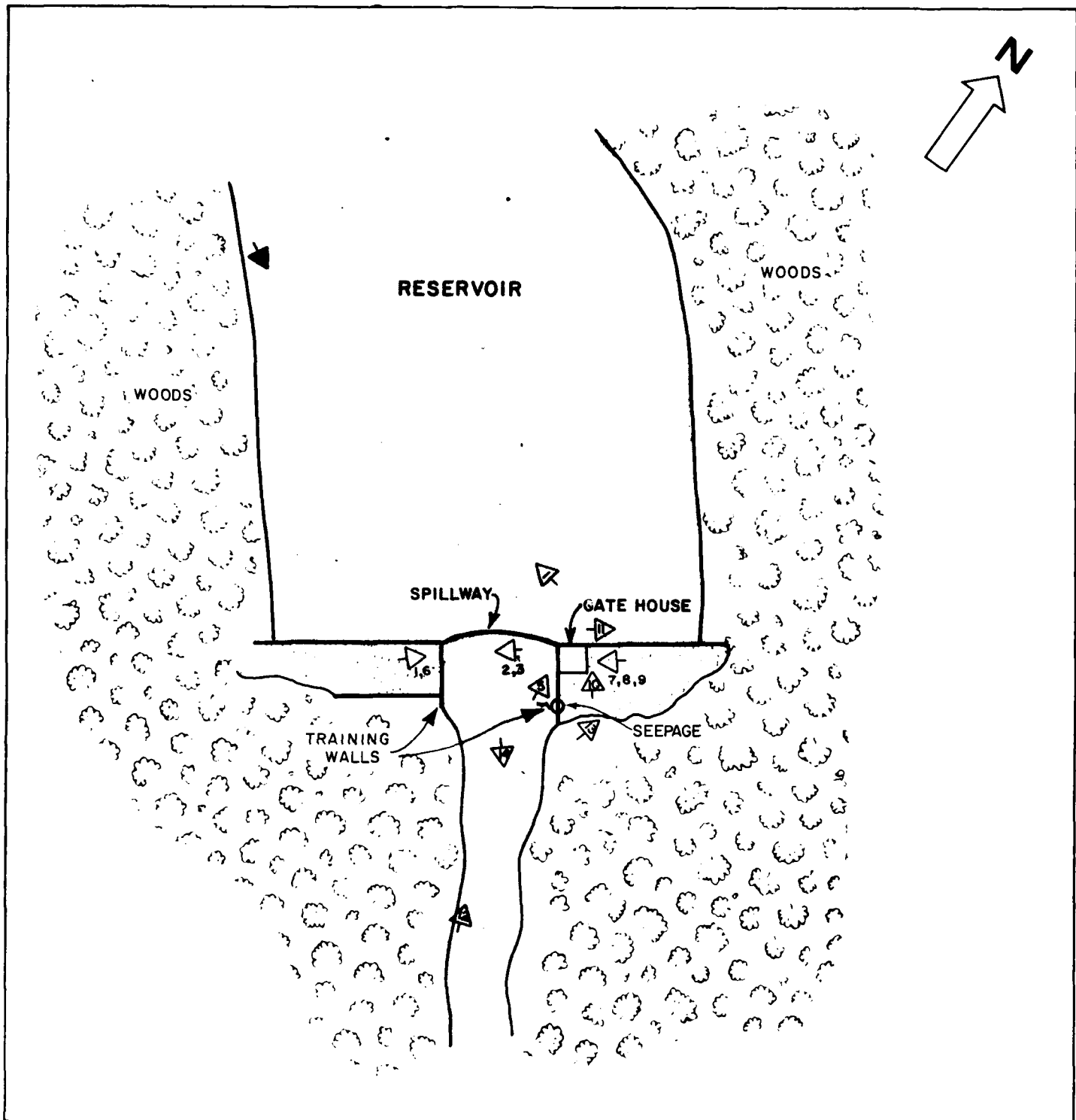
DISTRIBUTION - Send two completed copies to OEP regional office and one completed copy to State

TO: <b>OFFICE OF EMERGENCY PREPAREDNESS REGION <u>1</u></b>		FROM (Agency and/or Bureau and Location) <b>CORPS OF ENG. NED</b>	
1. APPLICANT <b>NORWICH FIRE DISTRICT</b>		2. DATE OF THIS REPORT <b>4 JAN 74</b>	
3. PROJECT APPLICATION NO. <b>OEP-377 DR-85</b>	4. DATE OF INITIAL DAMAGE SURVEY <b>18 JULY 74</b>	5. ORIGINAL ESTIMATED COST <b>\$15,565.00</b>	6. WORK ACCOMPLISHED BY <input checked="" type="checkbox"/> a. Contract <input type="checkbox"/> b. Force Account
7. INSPECTION MADE BY (Names and titles of inspecting officials) <b>J. DINGWALL C. OF E. NED A. TERRY VT. D.W.R.</b>		8. a. DATE OF FINAL INSPECTION <b>4 JAN 74</b> b. IS ACTIVITY IN OPERATION? <input checked="" type="checkbox"/> YES <input type="checkbox"/> NO	
9. WORK CATEGORY AND ITEM NO.(S). (Identify individual items of work per category which have been completed in accordance with the approved project application and the completion date for each.) <b>D2-1-S REF#5 EST. COST = 15,565.00 ACT. COST = \$8684.00</b>			
10. REMARKS (Explain all deviations or omissions from approved work. Use additional sheets if necessary) <b>WORK DONE WITHIN THE SCOPE DESCRIBED ON DSR. COST IS CONSISTANT WITH WORK ACCOMPLISHED.</b>			

## CERTIFICATION

THE ABOVE ITEM(S) IN THE PROJECT APPLICATION FOR THE CATEGORY OF WORK SHOWN HAS BEEN VISUALLY INSPECTED AND CERTIFICATION IS HEREBY MADE THAT THE WORK HAS BEEN COMPLETED AS APPROVED THEREIN, EXCEPT AS NOTED ABOVE.	
STATE INSPECTING OFFICIAL (Signature and title) <b>Robert L. Terry Water Resources</b>	DATE <b>4 Jan 74</b>
LOCAL INSPECTING OFFICIAL (Signature and title) <b>John C. Dingwall Pres. Norwich Fire District</b>	DATE <b>1/4/74</b>
FEDERAL AGENCY CONCURRENCE	
REVIEWING OFFICIAL (Signature) <b>John C. Dingwall</b>	TITLE <b>Corps of Engineers - N.E.D.</b>
NAME OF AGENCY (IF FEDERAL INSPECTOR NOT PRESENT DURING FINAL INSPECTION PLEASE EXPLAIN)	DATE <b>4 Jan 74</b>

APPENDIX C  
PHOTOGRAPHS



- OVERVIEW PHOTO  
 ▷ APPENDIX C PHOTO

GOLDBERG ZOINO & ASSOCIATES, INC. GEOTECHNICAL-GEOHYDROLOGICAL CONSULTANTS NEWTON UPPER FALLS, MASSACHUSETTS		U.S. ARMY ENGINEER DIV. NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MASSACHUSETTS	
NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS			
PHOTO LOCATION PLAN			
NORWICH RESERVOIR DAM		NORWICH VT.	
		SCALE 1" = 60'	
		DATE JUNE 1981	

FILE No 2605



1. Reservior Area. Note: Bowing  
of Trees



2. Crest of Spillway and Right Training Wall. Note: Thrust Wall and Embankment



3. Detail of Deteriorated Concrete on  
Right Training Wall



4. Crest of Spillway and Right Side of Gate House. Note: Deterioration of Concrete on Left Training Wall



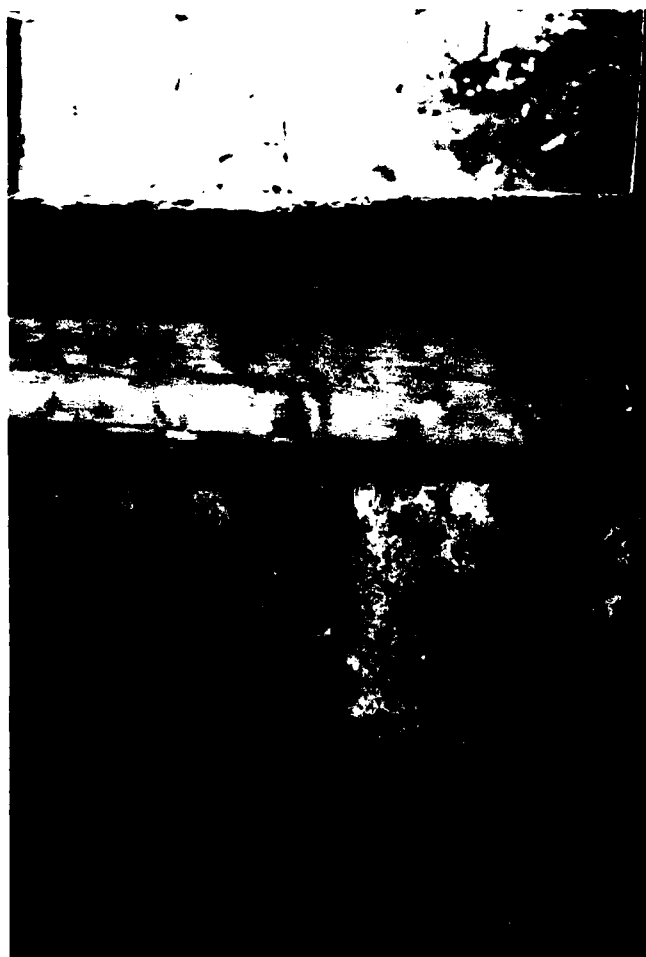
5. Detail of Deterioration of Concrete  
on Left Training Wall



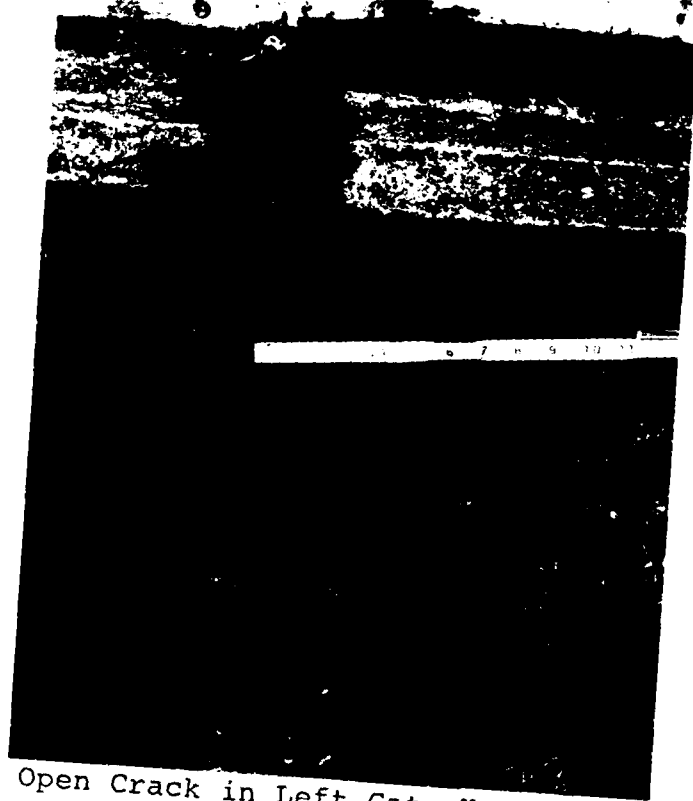
6. Left Training Wall



7. Gate House From Right Side



8. Crack in Right Gate House Wall

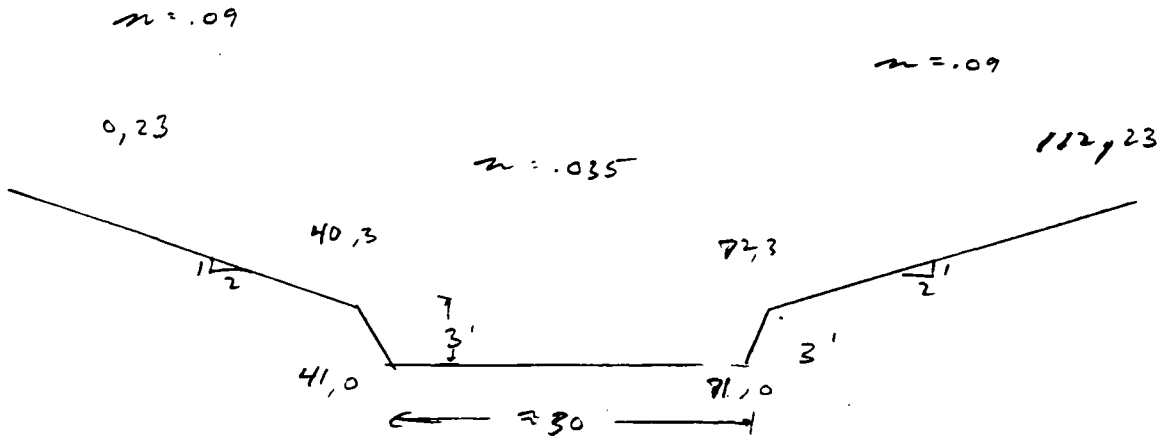


9. Open Crack in Left Gate House Wall



10. Open Crack in Left Gate House Wall  
Note: Rotational Movement

## Channel D/S of Norwich Dam



Channel Slope = .03

The stage-normal flow relationship for this reach is given on the next page. A pre-failure flow of 885 cfs would cause a stage of about 2.4 feet in the channel. At a failure flow of 12,985 cfs, the stage would rise 8.7 feet to a depth of 11.1 feet above the streambed.

The total storage volume behind the dam above the failure tailwater is approximately the storage volume at the non-overflow sections, 37.4 acre-feet. In the reach between the dam and the Meadow Road crossing 4,000 feet downstream, some attenuation of peak flow and a reduction in peak stage will occur. The calculations for attenuation are shown following the normal flow table. (Reach Storage = length x average area; Average area =  $\frac{\text{upstream} + \text{area downstream}}{2}$ . The area of the failure wave at the upstream end is 414 feet<sup>2</sup>.)

DAM FAILURE ANALYSIS

Assume failure occurs when the water surface is at the top of the non-overflow sections, 721.5 NGND.

Peak Failure Outflow = Normal Flow + Breach Outflow

From the Stage-Discharge curve, at elevation 721.5, Normal Flow = 885 cfs.

Breach Outflow

$$Q_{pi} = \frac{8}{27} \sqrt{g} W_b Y_o^{\frac{3}{2}}$$

Where:

$Y_o$  = water surface height above channel invert at failure

$Y_o$  = 27.5

$W_b \leq$  40% of the width at  $\frac{1}{2}$  height

width at  $\frac{1}{2}$  height = 125'

$W_b \leq .4(125) = 50'$

$Q_{pi} = \frac{8}{27} \sqrt{g} (50) (27.5)^{1.5}$

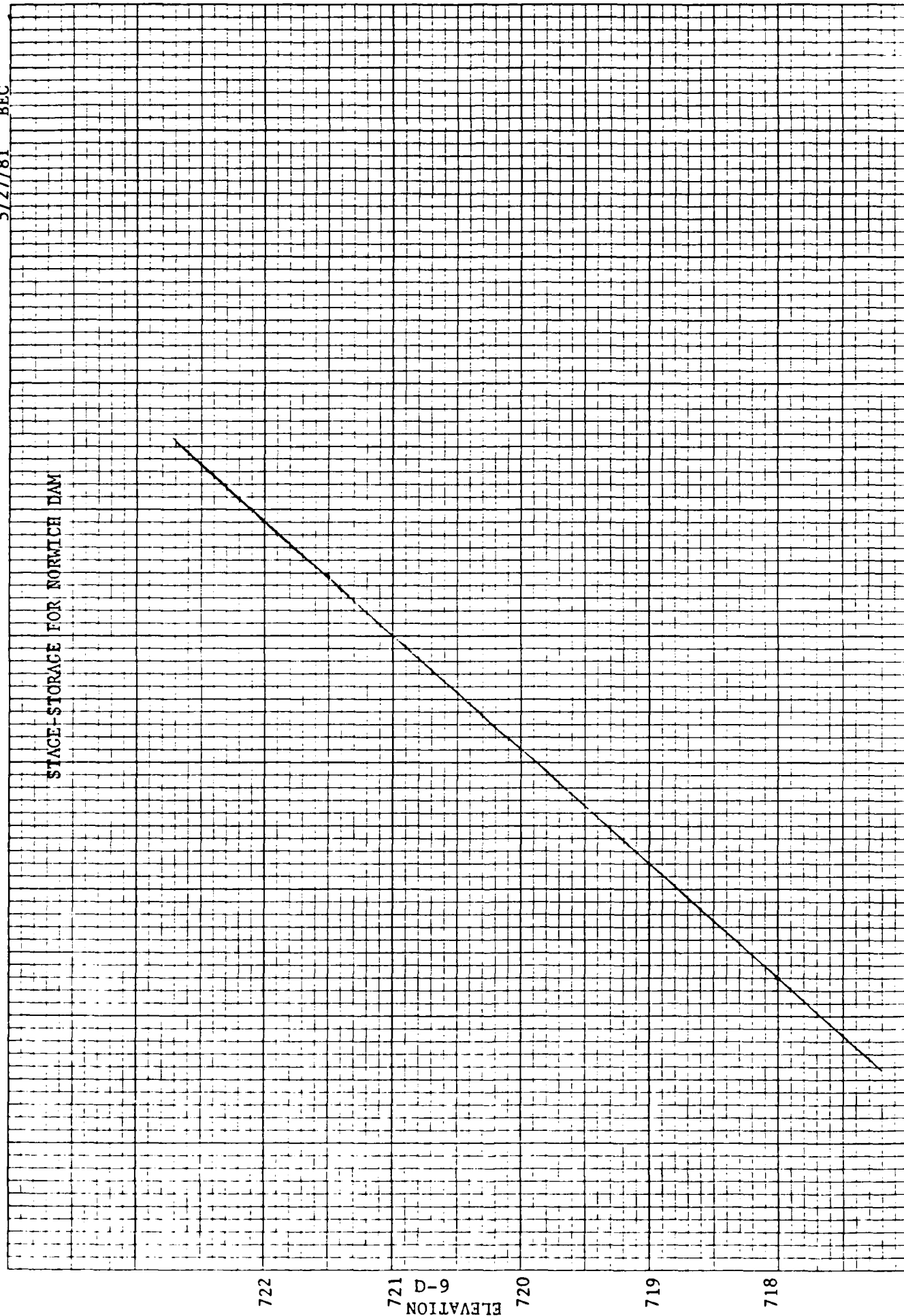
$Q_{pi} = 12,100$  cfs

Peak Failure Outflow = 12,100 + 885 = 12,985 cfs

On the next page is shown a typical cross-section for Brown Brook just downstream of the dam.

5/27/81 BEC

STAGE-STORAGE FOR NORWICH DAM



STAGE-STORAGE RELATIONSHIP

The normal storage behind Norwich Dam at the emergency spillway elevation (718) is about 21.5 acre-feet with a surface area of about 2.8 acres. At the crest of the non-overflow sections, 3.5 feet above the principal spillway, the storage volume would be about 37.4 acre-feet, with an area of 5.7 acres. Approximating this curve with a linear relationship for storage above the emergency spillway:

$$\text{surcharge storage} = 4.54 (\text{ELEV} - 718)$$

$$\text{Total storage} = 21.5 + 4.54(\text{ELEV} - 718)$$

For the drainage area of 5.2 square miles:

$$1" \text{ of runoff} = \frac{5.2(640)1"}{12("/\text{ft})} = 280 \text{ acre-feet}$$

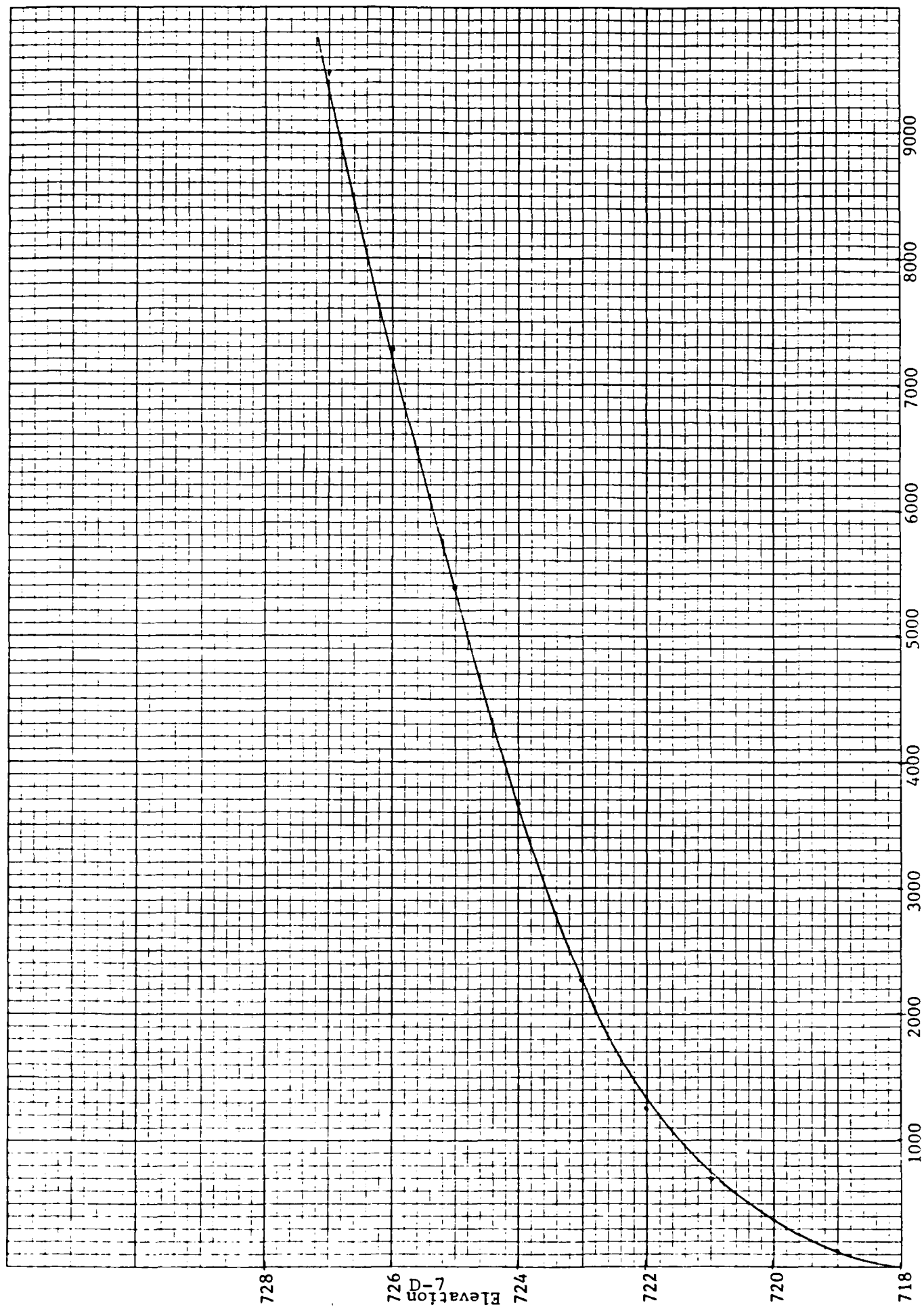
$$1 \text{ acre-feet} = \frac{1}{280} = .0036 \text{ inches of runoff}$$

Surcharge storage to the dam crest (ELEV = 721.5)

$$= 4.54(721.5 - 718) = 15.9 \text{ acre-feet} = .06 \text{ inches of runoff}$$

The stage-storage curve is shown on the next page.

STAGE-DISCHARGE CURVE FOR NORWICH DAM



# STAGE VS. DISCHARGE RELATIONSHIP FOR NORWICH DAM

HEAD (FT. ABOVE SPILLWAY)	ELEVATION	DISCHARGE (CFS)		
		SPILLWAY	NON-OVERFLOW	OVERBANKS TOTAL
0.00	718.00	0.00	0.00	0.00
0.50	718.50	47.73	0.00	47.73
1.00	719.00	135.00	0.00	135.00
1.50	719.50	248.01	0.00	248.01
2.00	720.00	381.84	0.00	381.84
2.50	720.50	533.63	0.00	533.63
3.00	721.00	701.48	0.00	701.48
3.50	721.50	883.97	0.00	883.97
4.00	722.00	1080.00	148.67	1229.72
4.50	722.50	1288.70	420.50	1715.14
5.00	723.00	1509.35	772.51	2298.22
5.50	723.50	1741.32	1189.35	2964.27
6.00	724.00	1984.09	1662.17	3704.96
6.50	724.50	2237.19	2184.98	4514.77
7.00	725.00	2500.23	2753.39	5389.75
7.50	725.50	2772.85	3364.00	6326.92
8.00	726.00	3054.70	4014.07	7323.92
8.50	726.50	3345.51	4701.33	8378.88
9.00	727.00	3645.00	5423.88	9490.26
9.50	727.50	3952.93	6180.06	10656.77
10.00	728.00	4269.07	6968.45	11877.33

```

100 REM STAGE/DISCHARGE CURVE FOR NORWICH DAM
110 REM - STORED ON TAPE B-1 FILE 24
120 PAGE
130 PRINT USING 140,
140 IMAGE 10T"STAGE VS.DISCHARGE RELATIONSHIP FOR NORWICH DAM"
150 PRINT USING 160,
160 IMAGE /2T"HEAD"10T"ELEVATION"47T"DISCHARGE"
170 PRINT USING 180,
180 IMAGE "(FT. ABOVE"49T"(CFS)"
190 PRINT USING 200,
200 IMAGE"SPILLWAY)"
210 PRINT USING 220,
220 IMAGE 28T"SPILLWAY"45T"NON-OVERFLOW"60T"OVERBANKS"73T"TOTAL"//
230 FOR H=0 TO 10 STEP 0.5
240 01=0
250 02=0
260 03=0
270 04=0
280 05=0
290 E1=H+718
300 01=3*45*H↑1.5
310 IF H<3.5 THEN 340
320 02=2.9*145*(H-3.5)↑1.5
330 03=2.8*(H-3.5)*6*(0.5*(H-3.5))↑1.5
340 04=01+02+03
350 PRINT USING 360:H,E1,01,02,03,04
360 IMAGE 20.2D,08D.2D,15D.2D,10D.2D,100.2D
370 NEXT H
380 END

```

STAGE-DISCHARGE CURVE

For the purposes of this study, the 10 inch intake and 20 inch outlet pipe will be assumed closed during flood conditions. The weir equations describing the existing dam are:

from  $H = 0$  to  $H = 3.5$

$$Q_1 = 3.0 (45) (H)^{1.5} \quad (\text{spillway section, el} = 718.0)$$

above  $H = 3.5$

$$Q_1 = 3.0 (45) (H)^{1.5}$$

$$Q_2 = 2.9 (145) (H - 3.5)^{1.5} \quad (\text{non-overflow abutments})$$

$$Q_3 = 2.8 (H - 3.5) (4) \left(\frac{1}{2}(H - 3.5)\right)^{1.5} + 2.8 (H - 3.5) (2) \left(\frac{1}{2}(H - 3.5)\right)^{1.5}$$

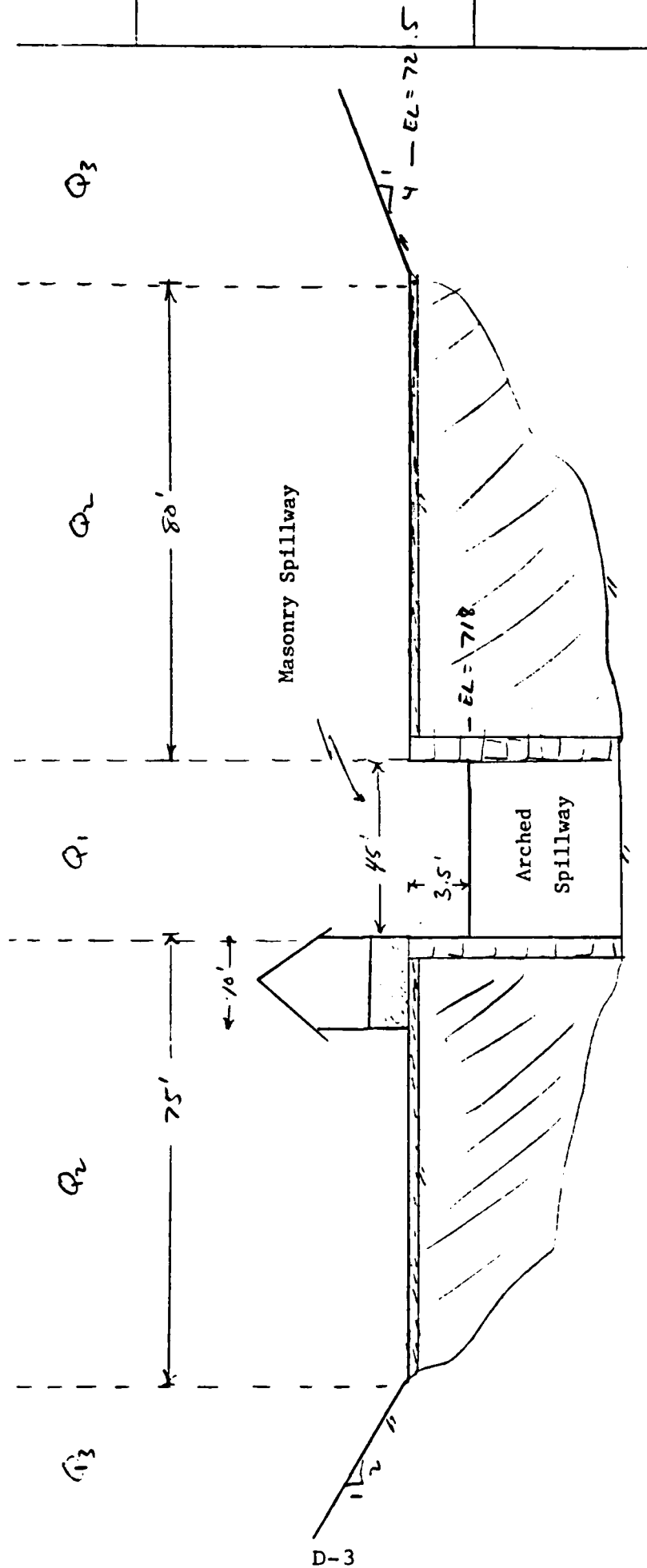
(overbanks)

$H$  = feet above principal spillway

On the following pages are the dam rating table, BASIC program, and the stage-discharge curve.

# NORWICH RESERVOIR

(Looking Downstream)



## NORWICH RESERVOIR

The Norwich Reservoir Dam is an earthfill and masonry wall structure with an overall length of 200 feet. A 45 foot long arched spillway section serves as the principal and emergency spillway at an elevation of 718 NGVD. This is 3.5 feet below two non-overflow sections, one on the left that extends about 75 feet from the natural valley to the left abutment including a 10 foot gate house, and one on the right which extends about 80 feet from the natural valley to the right abutment. The height of the dam is 27.5 feet from the dam toe to the top of the non-overflow section. A sketch of the dam is shown on the next page.

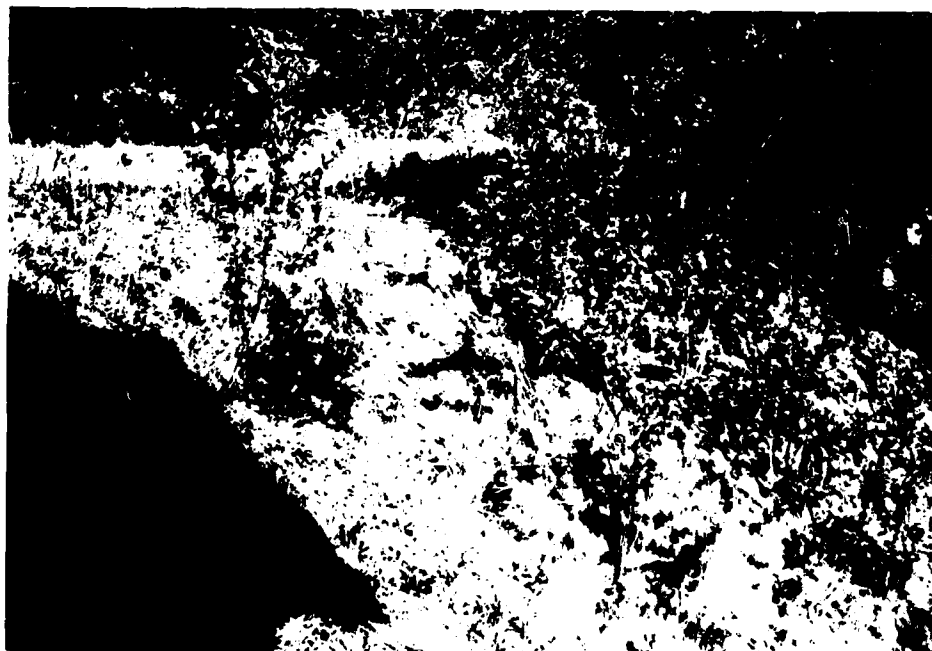
APPENDIX D  
HYDROLOGIC AND HYDRAULIC COMPUTATIONS



14. Downstream Channel



12. Downstream View of Spillway



13. Downstream Slope of Left Embankment  
Note: Brush and Tree Growth



11. Left Thrust Wall From Gate House

CHANNEL DOWNSTREAM OF NORWICH DAM

===== DATA FOR THE COMBINED SYSTEM =====

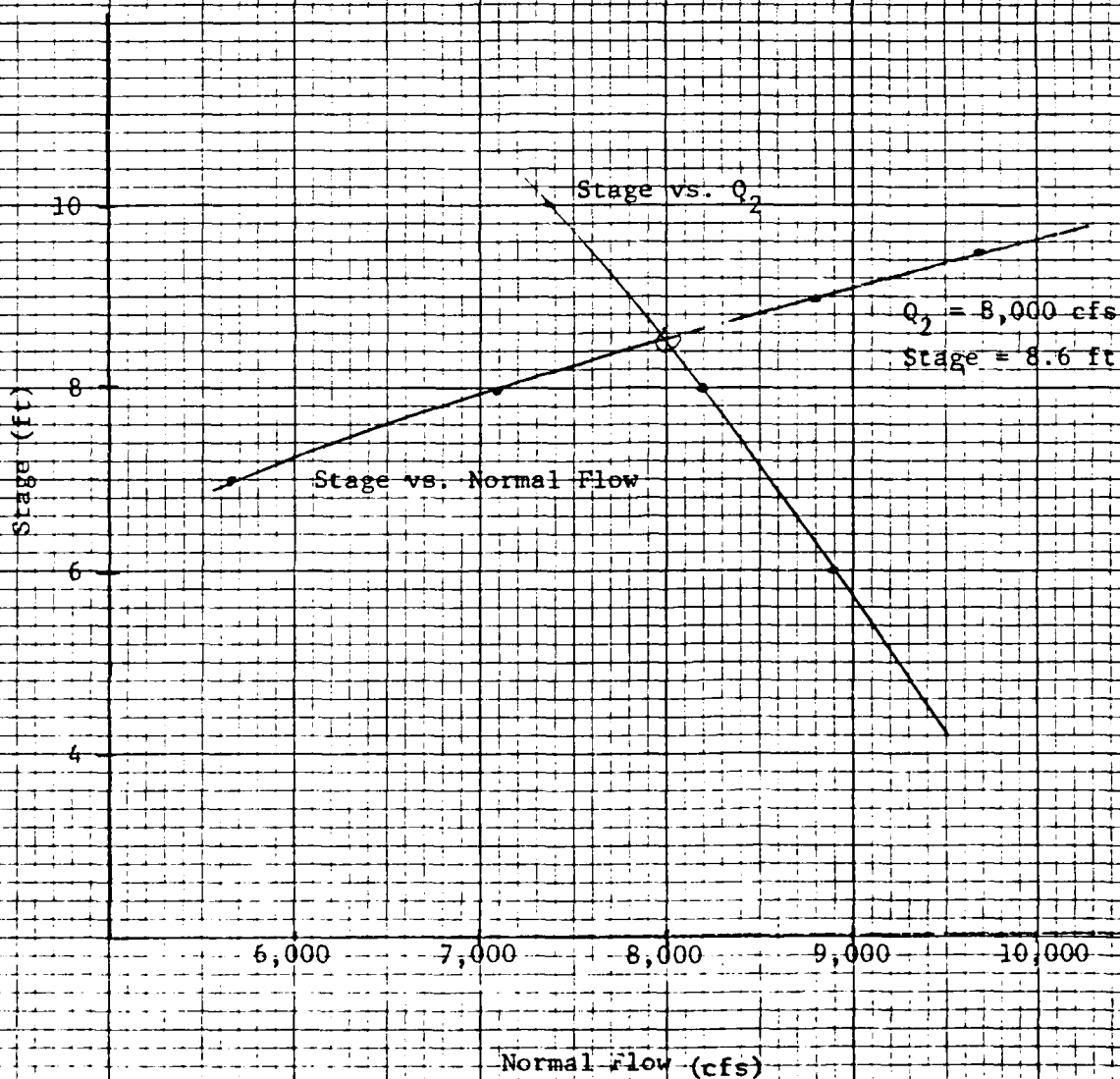
DEPTH ft.	ELEV ft.	AREA ft <sup>2</sup>	WPER ft.	HYD-R ft.	AR2/3	Q cfs
0.00	0.0	0.0	0.0	0.0	0.0	0.0
0.50	0.5	15.1	31.1	0.5	9.3	69.9
1.00	1.0	30.3	32.1	0.9	29.2	218.9
1.50	1.5	45.8	33.2	1.4	56.7	425.0
2.00	2.0	61.3	34.2	1.8	90.5	678.4
2.50	2.5	77.1	35.3	2.2	129.8	973.1
3.00	3.0	93.0	36.3	2.6	174.0	1304.6
3.50	3.5	109.5	38.6	2.8	219.6	1700.3
4.00	4.0	127.0	40.8	3.1	270.8	2139.1
4.50	4.5	145.5	43.0	3.4	327.8	2620.5
5.00	5.0	165.0	45.3	3.6	390.8	3144.3
5.50	5.5	185.5	47.5	3.9	460.0	3710.1
6.00	6.0	207.0	49.7	4.2	535.6	4317.8
6.50	6.5	229.5	52.0	4.4	617.7	4967.2
7.00	7.0	253.0	54.2	4.7	706.5	5658.4
7.50	7.5	277.5	56.4	4.9	802.3	6391.2
8.00	8.0	303.0	58.7	5.2	905.2	7165.9
8.50	8.5	329.5	60.9	5.4	1015.3	7982.3
9.00	9.0	357.0	63.2	5.7	1132.8	8840.6
9.50	9.5	385.5	65.4	5.9	1258.0	9741.0
10.00	10.0	415.0	67.6	6.1	1391.0	10683.6
10.50	10.5	445.5	69.9	6.4	1531.9	11668.6
11.00	11.0	477.0	72.1	6.6	1681.0	12696.2
11.50	11.5	509.5	74.3	6.9	1838.4	13766.5
12.00	12.0	543.0	76.6	7.1	2004.2	14879.8
12.50	12.5	577.5	78.8	7.3	2178.7	16036.3
13.00	13.0	613.0	81.0	7.6	2362.0	17236.3
13.50	13.5	649.5	83.3	7.8	2554.3	18479.9
14.00	14.0	687.0	85.5	8.0	2755.7	19767.5
14.50	14.5	725.5	87.8	8.3	2966.3	21099.3
15.00	15.0	765.0	90.0	8.5	3186.5	22475.5

# ATTENUATED PEAK DAM FAILURE FLOW 2,000 FEET DOWNSTREAM

$$Q_2 = 885 - Q_{p1} \left(1 - \frac{STOR}{37.4}\right) = 885 + 12,100 \left(1 - \frac{STOR}{37.4}\right)$$

\* STOR = Stream Storage increase due to dam failure (acre-feet)

Stage	Area above depth = 11.9 (ft <sup>2</sup> ) (AREA - 72 ft <sup>2</sup> )	STOR = $\frac{AREA + 414,2000}{2}$	Q <sub>2</sub> (cfs)
8	231	14.8	8,200
6	135	12.6	8,900
4	55	10.8	9,500
10	343	17.4	7,360

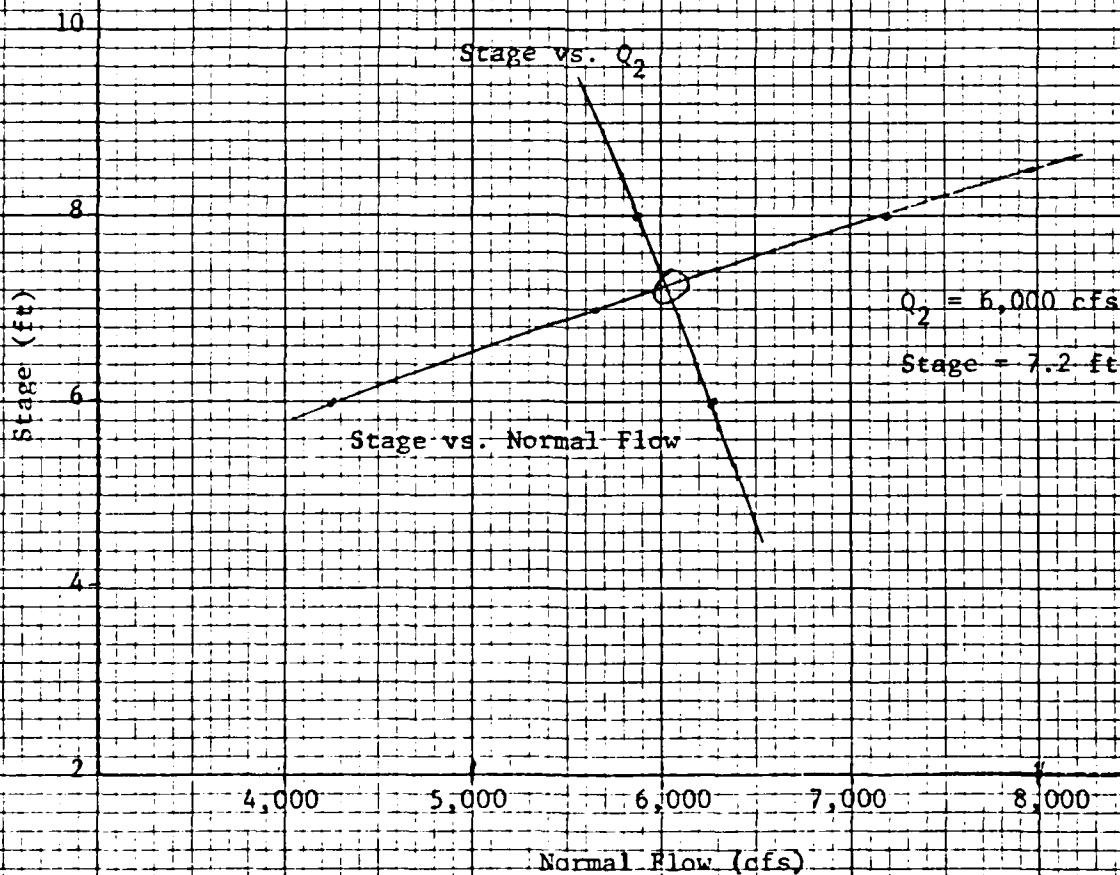


# ATTENUATED PEAK DAM FAILURE FLOW 4,000 FEET DOWNSTREAM

$$Q_2 = 885 + 0.1 \left( 1 - \frac{STOR}{37.4} \right) = 885 + 7,115 \left( 1 - \frac{STOR^*}{37.4} \right)$$

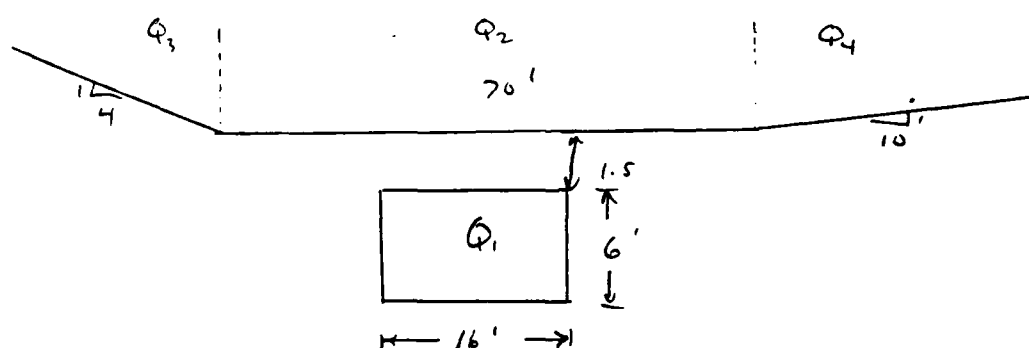
\*STOR = Stream Storage Increase due to failure (acre-feet)

Stage	Area above depth = 11.9 (ft <sup>2</sup> ) (AREA = 72 ft <sup>2</sup> )	STOR = $\frac{AREA + 258,2000}{2}$	Q <sub>2</sub> (cfs)
8	231	11.2	5,860
6	135	9.0	6,280



The attenuated dam failure flow at the end of this reach would be 6,000 cfs with a stage of about 7.2 feet. One house is located on the left bank within this reach, but it is sufficiently high enough to escape damage due to the dam failure. A ponding structure, however, used by the town for recreation, would probably be destroyed by the failure wave.

At the end of the 4,000 foot reach, Brown Brook flows through a 16 foot wide by 6 foot high culvert with a low chord 1.5 feet lower than Beaver Meadow Road. Although the attenuated stage is about 7.2 feet, the peak flow of 6,000 cfs would quickly fill the culvert beyond its capacity and raise the peak stage considerably. Shown below is a cross section of this culvert.



Using HEC-5, Hydraulic Charts for the Selection of Highway Culverts, and the following weir formulas:

$$Q_2 = 2.9 (70) (H)^{1.5}$$

$$Q_3 = 2.9 (H) (4) (.5H)^{1.5}$$

$$Q_4 = 2.9 (H) (10) (.5H)^{1.5}$$

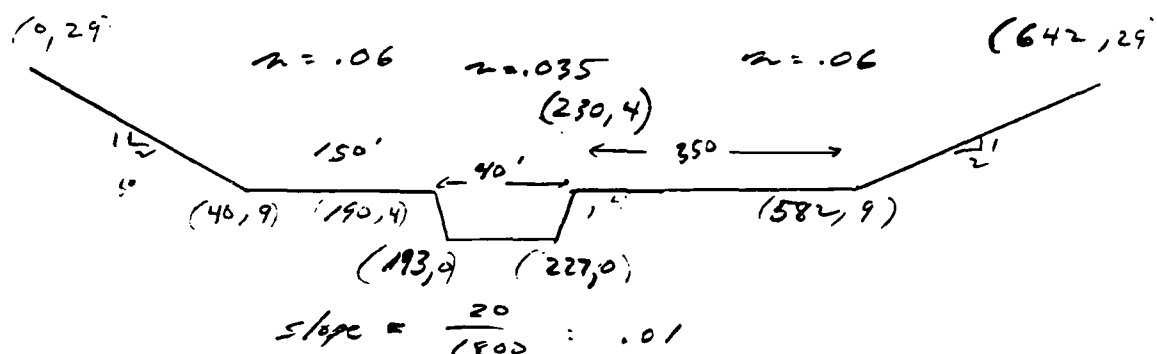
The following rating table results:

<u>Stage Ft. above Streambed</u>	<u>(HW/D)</u>	<u>H Ft. above road</u>	<u>Q<sub>1</sub></u>	<u>Q<sub>2</sub></u>	<u>Q<sub>3</sub> + Q<sub>4</sub></u>	<u>Q<sub>T</sub></u>
7.5	1.25	0	800	0	0	800
8.5	1.42	1	960	205	15	1180
9.5	1.58	2	1090	575	85	1750
10.5	1.75	3	1140	1055	225	2420
11.5	1.92	4	1250	1625	460	3335
12.5	2.08	5	1310	2270	805	4385
13.5	2.25	6	1410	2985	1265	5660
14.0	2.33	6.5	1460	3365	1545	6370

As can be seen in the rating table, a failure flow wave of 6,000 cfs would create a head of about 6.2 feet over the road. A house located on the right bank and at the road elevation would probably receive severe damage, and the possibility for loss of life would be significant.

About 700 feet downstream of the bridge, Brown Brook joins Bloody Brook. Just downstream of this confluence, a small wooden deck bridge crosses Bloody Brook. The stages in this area would probably be similar to stages created at the Beaver Meadow Road crossing, so the 5 houses located on the right bank between the two structures would probably suffer some damage.

Downstream of the wooden deck bridge, the gradient of Bloody Brook flattens out and the overbanks become wide and nearly level. A typical section is shown below.



A stage-normal flow table for this section is shown on the next page. The next downstream reach, about 1800 feet long, includes tennis courts and a recreation area on the left bank. Adjacent to this reach is a residential housing area, where 6 houses are located at the level of the stream banks. The attenuation for this reach is shown on the page following the rating table. It is assumed that Bloody Brook is flowing at a depth of 3 feet, with a flow rate of 880 cfs and an area of 109 ft<sup>2</sup> prior to the failure of Norwich Reservoir Dam. Near the vicinity of the wooden bridge, from the rating table it can be seen that a peak failure flow of 6880 cfs would create a stage of about 7.6 feet. At the end of this reach, the attenuated peak flow is 3900 cfs with a stage of 6.3 feet.

TENNIS COURT REACH

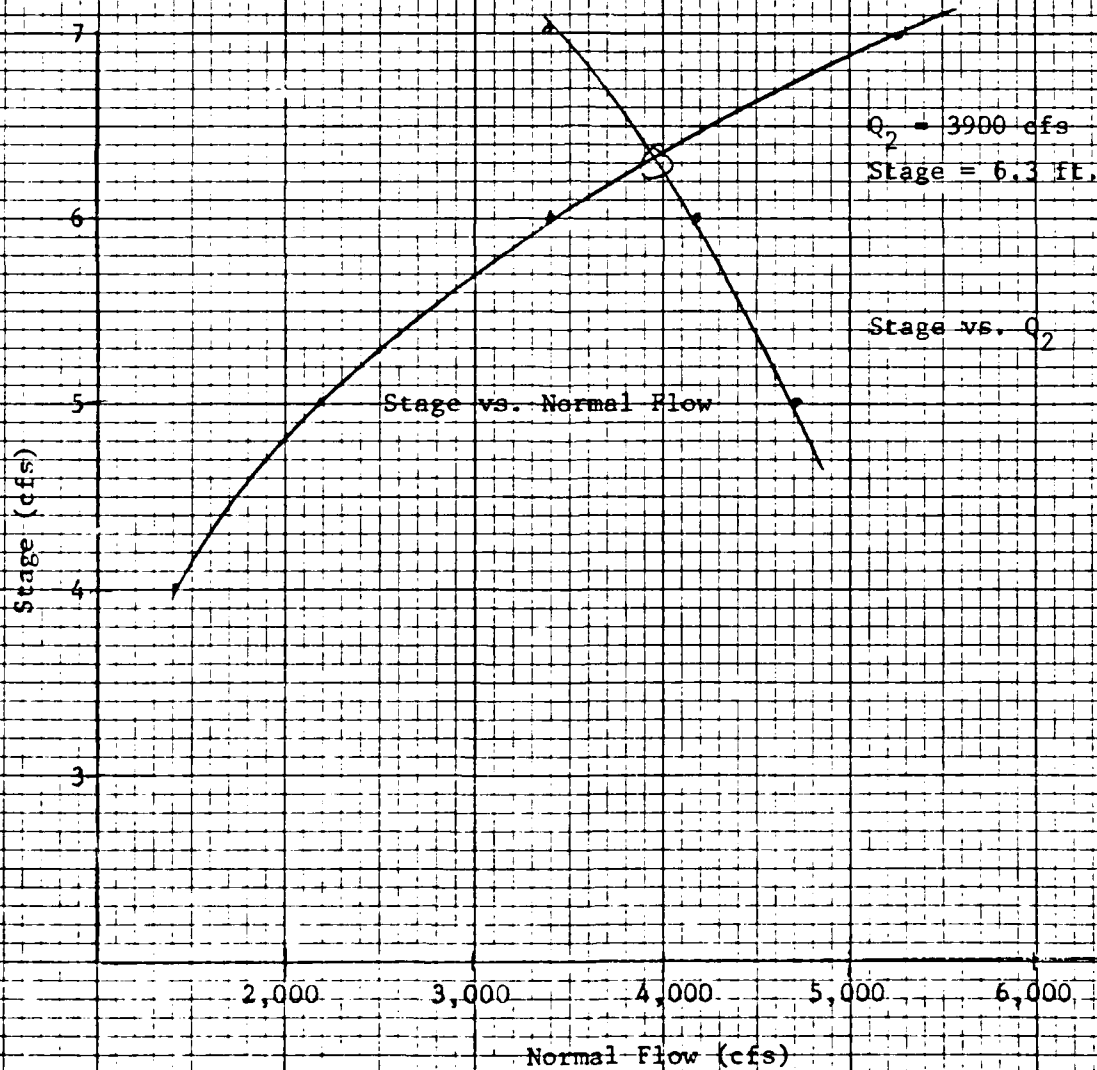
===== DATA FOR THE COMBINED SYSTEM =====

DEPTH ft.	ELEV ft.	AREA ft <sup>2</sup>	WPER ft.	HYD-R ft.	AR2/3	O cfs
0.00	0.0	0.0	0.0	0.0	0.0	0.0
0.50	0.5	17.2	35.3	0.5	10.6	45.3
1.00	1.0	34.8	36.5	1.0	33.6	143.2
1.50	1.5	52.7	37.8	1.4	65.8	280.1
2.00	2.0	71.0	39.0	1.8	105.9	450.7
2.50	2.5	89.7	40.3	2.2	153.0	651.4
3.00	3.0	108.8	41.5	2.6	206.7	880.0
3.50	3.5	128.2	42.8	3.0	266.6	1134.8
4.00	4.0	148.0	44.0	3.4	332.3	1414.5
4.50	4.5	180.6	94.2	1.9	278.6	1759.6
5.00	5.0	238.2	144.4	1.6	332.5	2186.0
5.50	5.5	321.0	194.6	1.6	448.0	2725.8
6.00	6.0	428.8	244.8	1.8	623.0	3405.3
6.50	6.5	561.8	295.1	1.9	862.9	4247.9
7.00	7.0	719.8	345.3	2.1	1174.7	5275.4
7.50	7.5	903.0	395.5	2.3	1565.6	6507.8
8.00	8.0	1111.2	445.7	2.5	2043.1	7964.2
8.50	8.5	1344.6	495.9	2.7	2614.3	9662.9
9.00	9.0	1603.0	546.1	2.9	3286.2	11621.4
9.50	9.5	1874.6	548.8	3.4	4251.8	14211.4
10.00	10.0	2147.5	551.5	3.9	5315.2	17060.0
10.50	10.5	2421.6	554.2	4.4	6472.3	20155.6
11.00	11.0	2697.0	556.9	4.8	7719.9	23488.6
11.50	11.5	2973.6	559.6	5.3	9055.0	27051.1
12.00	12.0	3251.5	562.3	5.8	10475.1	30836.2
12.50	12.5	3530.6	565.0	6.2	11978.0	34837.8
13.00	13.0	3811.0	567.7	6.7	13561.7	39050.6
13.50	13.5	4092.6	570.4	7.2	15224.7	43470.1
14.00	14.0	4375.5	573.1	7.6	16965.1	48091.8
14.50	14.5	4659.6	575.8	8.1	18781.7	52912.2
15.00	15.0	4945.0	578.5	8.5	20673.2	57927.6

# REACH NEAR TENNIS COURTS

$$Q_2 = 1765 + 5115 \left(1 - \frac{\text{STOR}}{37.4}\right)$$

Stage	Area above 4.5 feet (sq. ft.) (AREA - 181)	STOR = $\frac{\text{AREA} + 708}{2}$	$\frac{1800}{43560}$	$Q_2$ (cfs)
6	248	19.8		4,170
5	57	15.8		4,720
7	539	25.8		3,360



A peak flow of this magnitude and stage would cause heavy damage to the residential housing site on the right bank. In addition, a potential for loss of life exists. Several more houses are located along the banks from the end of this reach to the downstream crossing of Beaver Meadow Road. The cross-section used for the upper reach of this section (tennis court area) can also be used here. As previously noted, the peak flow at the upper end of this section is 3900 cfs with a stage of 6.3 feet. The calculations for the attenuated peak flow at Beaver Meadow Road, 2,000 feet downstream are shown on the next page. The area above the normal flow area in the stream at the upstream end is  $507 - 181 = 326 \text{ ft}^2$ . (Area at 3900 cfs = 507 sq. feet.) The attenuated peak flow at the Beaver Meadow Road crossing is 3,200 cfs with a stage of 5.8 feet.

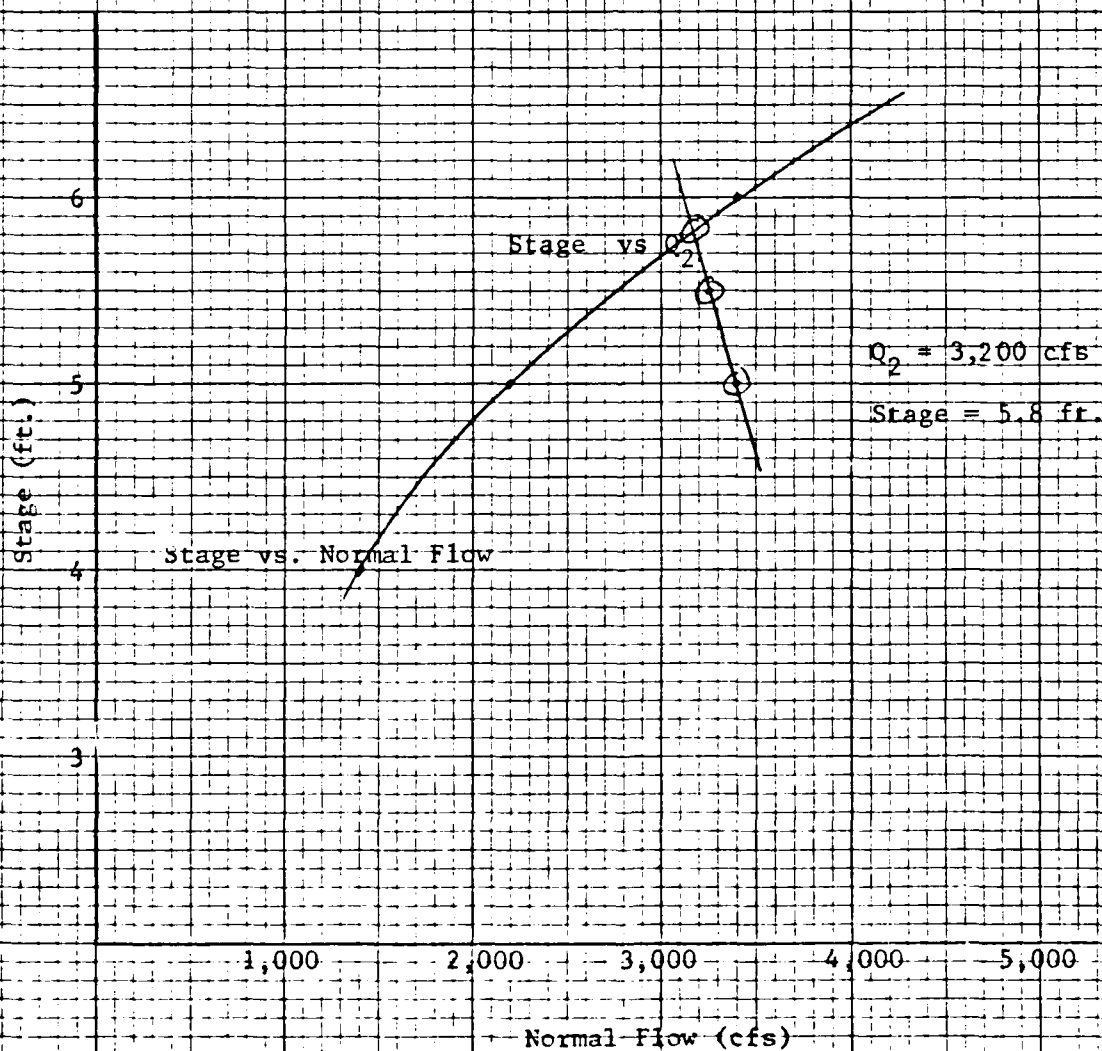
Located on the left bank of this downstream reach is a church at the streambank level, which would receive flood damage. Backwater conditions from Beaver Meadow Road also have the potential of raising the stage higher and causing further damage.

Roadway damage at Beaver Brook and at each of the next four other stream crossings downstream is likely to occur due to the magnitude of the peak failure flow. Residential houses downstream, however, are located above the river stages that would cause severe damage, although some minor flooding may occur.

# REACH DOWNSTREAM OF TENNIS COURTS

$$Q_2 = 1765 + 2135 \left(1 - \frac{\text{STOR}}{37.4}\right)$$

Stage	Area above 4.5 feet (sq. ft.) (AREA = 181)	STOR = $\frac{\text{AREA} + 326}{2} \frac{2000}{43560}$	Q <sub>2</sub> (cfs)
5	57	8.8	3,400
5.5	140	10.7	3,290



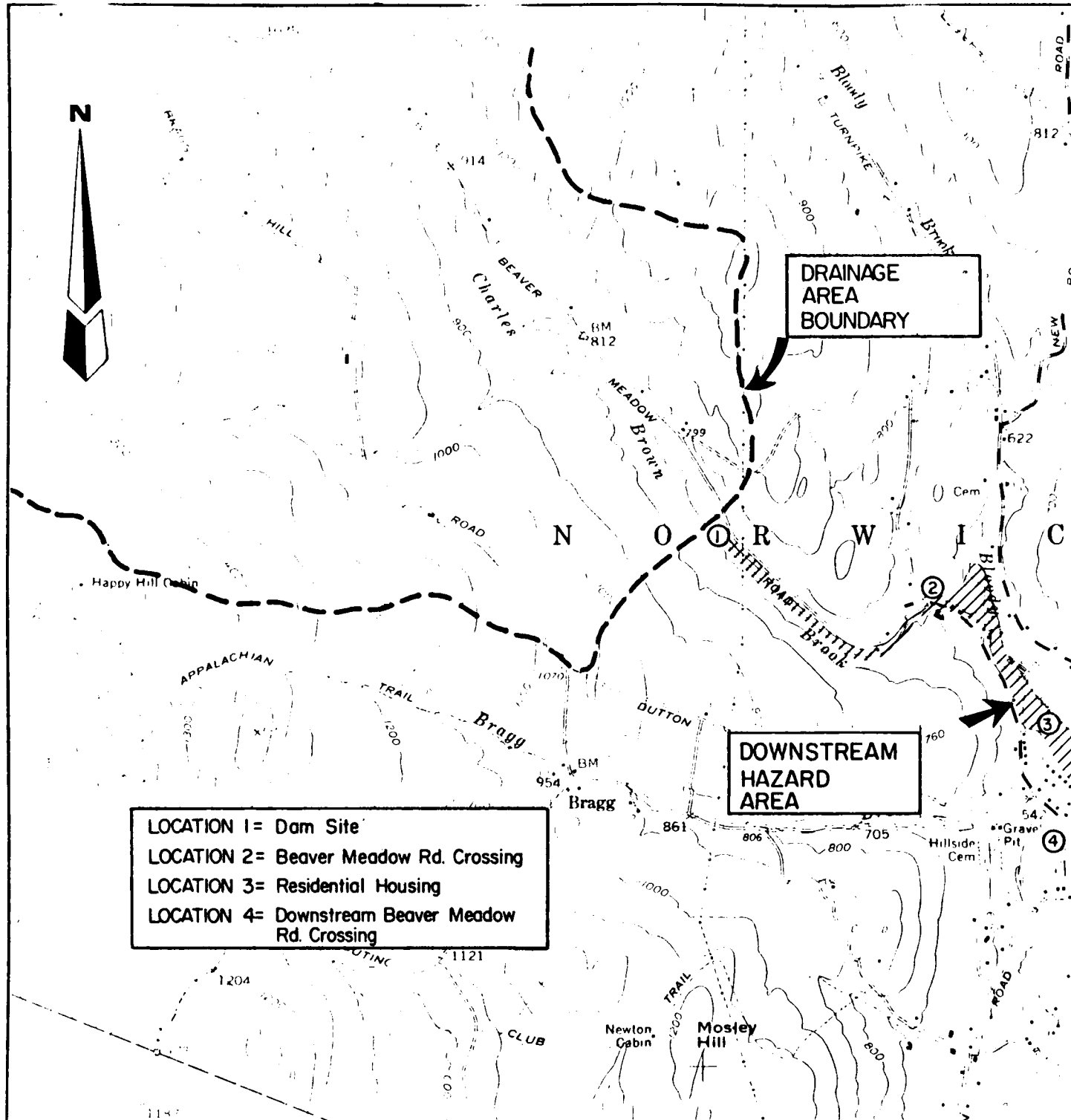
Test Flood Analysis

Size Classification: SMALL (Storage less than 50 acre-feet; height less than 40 feet).

Hazard Classification: HIGH

The failure of Norwich Dam with the water surface prior to failure at the top of the non-overflow sections would cause severe flooding downstream. Nearly all of the stream crossing structures on Brown Brook and Bloody Brook would be destroyed and road service in this area would be cut off. Life threatening flooding is expected to occur at the Beaver Meadow Road culvert on Brown Brook, upstream of the wooden decked bridge on Bloody Brook, and in the residential area on the right bank of Bloody Brook, upstream of the second Beaver Meadow Brook crossing.

The appropriate Test Flood for a dam classified as SMALL in size with a HIGH hazard potential would be between  $\frac{1}{2}$  the Probable Maximum Flood (PMF) and the PMF. Due to the rather small storage capacity of the dam, one-half of the PMF is used as the Test Flood. With a drainage area of 5.2 square miles and mountainous terrain, the Corps of Engineers' PMF curve suggests a 2,200 cfs/sq. mile for the PMF. One-half the PMF would be  $(\frac{2200}{2}) \times 5.2 = 5750$  cfs. The small storage capacity of the dam would have little effect on the Test flood inflow so the routed peak Test Flood outflow would also be 5750 cfs. The water surface elevation which results from this flood (see the dam rating curve) would be about 725.2 NGVD, which is 3.7 feet above the non-overflow sections and 7.2 feet above the main spillway. The normal spillway capacity of 885 cfs is only 15 percent of the peak Test Flood outflow.



- LOCATION 1= Dam Site  
 LOCATION 2= Beaver Meadow Rd. Crossing  
 LOCATION 3= Residential Housing  
 LOCATION 4= Downstream Beaver Meadow Rd. Crossing

-SCALE-  
 0 1000 2000 4000(FT.)

FROM: USGS HANOVER, VT-NH  
 QUADRANGLE MAP

GOLDBERG-ZOINO & ASSOCIATES, INC.  
 GEOTECHNICAL-GEOHYDROLOGICAL CONSULTANTS  
 NEWTON UPPER FALLS, MASSACHUSETTS

U.S. ARMY ENGINEER DIV. NEW ENGLAND  
 CORPS OF ENGINEERS  
 WALTHAM, MASSACHUSETTS

NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

## DOWNSTREAM HAZARD MAP

NORWICH RESERVOIR DAM

NORWICH, VERMONT

SCALE AS NOTED

DATE MAY 1981

FILE No. 2605

APPENDIX E

INFORMATION AS CONTAINED IN  
THE NATIONAL INVENTORY OF DAMS

**END**

**FILMED**

**8-85**

**DTIC**